Avionics SCOE Requirements Specification

CI CODE: 13000
DRL Refs :

UK EXPORT CONTROL RATING : Not Listed
Rated By : D. Perkins

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1 INTRODUCTION AND SCOPE

1.1 Introduction

This document establishes the design, performance, interface and verification requirements for the Avionics SCOE for the Gaia Project.

The Avionics SCOE is a primary element of a model-based architecture capable of modelling the satellite mission environment.

Gaia is a scientific mission of the European Space Agency (ESA) which will rely on the proven principles of the previous Hipparcos mission to create an extraordinarily precise three-dimensional map of about one billion stars throughout our galaxy and beyond.

Gaia will provide astrometric measurements of all objects to 20 mag, with multicolour multi-epoch photometry and radial velocities for objects brighter than 16-17 mag. Accuracies are better than 10 microarcsec at 15 mag. The envisaged experimental operations principle is a continuous scanning of the sky on great-circles with constant inclination to the Sun. Mainly because of the high thermal stability requirements, the current orbit baseline, a Lissajous orbit around the L2 Libration point in the Earth-sun system has been selected.

1.2 Scope

The document in hand comprises the contractually relevant technical requirements and constraints for the Gaia Avionics SCOE. This includes:

- The performance, design and interface requirements.
- The testing and verification requirements.

Requirements within this document are shown in an italic font. Each requirement is preceded by a summary line that contains:

- The Doors Requirement Number, in the form AVI-xxx/', where xxx is a unique number.
- A link to the upper level user requirements document, in the form 'GSE-SYS-xxx/', where applicable, or 'CREATED/' if not.
- The Verification Method(s) to be applied for the requirement, using codes as follows: (where more than one method is listed, all shall apply)
  - **T** - Test
  - **A** - Analysis
  - **R** - Review
  - **I** - Inspection
  - **S** - Similarity

The requirement text follows the summary line. If tables are considered as part of requirement they are referenced clearly in the text and inserted after and separated from the requirement and are managed as free text attached to the identifier requirement.

All document elements, which are not presented in the format explained above are not requirements and will not be verified or tracked.

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1.3 Summary Description

The Avionics SCOE is used during various stages of Spacecraft build to allow testing of the Gaia Avionics Subsystem in open-loop and closed-loop mode. It comprises the following test features:

Simulation and measurement of the AOCS Actuators.
Stimulation of the AOCS Sensors inputs.
Acquisition of data from the CDMU MIL-STD-1553B Data BUS (Payload and Service Module).
Simulation of data on the CDMU MIL-STD-1553B Data BUS (Payload and Service Module).
Acquisition of data on the CDMU-EIU SpaceWire BUS.
Simulation of data on the CDMU-EIU SpaceWire BUS.
Acquisition of data on the CDMU-PDHU PacketWire BUS.
Simulation of data on the CDMU-PDHU PacketWire BUS.

1.4 Gaia Test Benches

Using a model-based test philosophy, the following Test Benches are identified for Avionics SCOE usage:

- Avionics Model Bench (AVM) - see Figure 1.4-1.
- Spacecraft PFM AIT.

1.4.1 Avionics Model Bench

The AVM is a test bed built up from (as a minimum) the Spacecraft CDMU up to (eventually) a full set of Spacecraft electronics units and associated harness.

In the AVM configuration, the Avionics SCOE is used to perform open-loop and closed-loop testing of the Spacecraft Avionics.

For open-loop testing, the Avionics SCOE is controlled locally or from the CCS.

For closed-loop testing, the Spacecraft Interfaces provided by the Avionics SCOE are under the control of the Real Time Simulator (RTS).

In this configuration, Test Procedures developed on the CCS during AVM testing are intended for use throughout the Spacecraft AIT campaign.

Figure 1.4-1 shows a block diagram of the Gaia EGSE Configuration and the Avionics SCOE interfaces to the Gaia Spacecraft and other EGSE.

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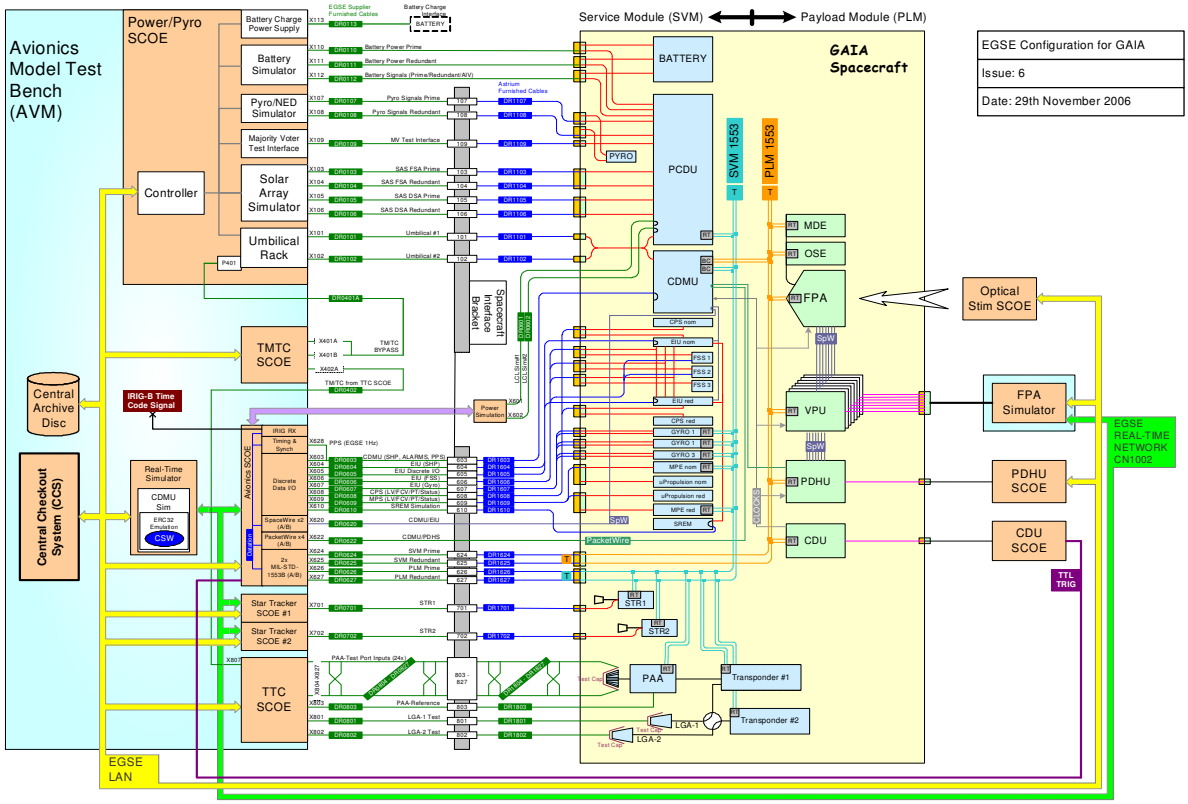

Figure 1.4-1: Gaia EGSE Configuration

1.4.2 Spacecraft PFM AIT

During the Spacecraft PFM AIT test campaign, the RTS is used to Model the Spacecraft Mission Environment and Dynamics and the AOCS Actuators and Sensors (which remain simulated throughout). In addition, any missing Spacecraft units may be modelled. Using direct electronic stimulation and measurement provided by the Avionics SCOE and other EGSE, it allows closed-loop testing of the Spacecraft Avionics.

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2 DOCUMENTS

The following documents are applicable documents to this specification. Those parts of the documents that are specifically applicable for the subcontractor's product design, test, and manufacturing, are clearly defined by references within this specification.

2.1 Project Documents

2.1.1 Applicable Documents

AD01	GAIA EGSE Interface Control Document	GAIA.ASU.ICD.ESM.00001 Issue 3 Revision 0
AD02	GAIA EGSE General Design and Interface Requirements (GDIR) Specification	GAIA.ASF.SP.SAT.00007 Issue 3 Revision 0
AD03	GAIA Product Assurance Requirements for Ground Support Subcontractors	GAIA.ASF.SP.SAT.00037 Issue 2 Revision 0
AD04	GAIA S/W Product Assurance Requirements for EGSE/OGSE Software	GAIA.ASF.SP.SAT.00046 Issue 1 Revision 0
AD05	GAIA MIL-STD-1553B Bus Protocol Specification	GAIA.ASF.SP.SAT.00059 Issue 2 Revision 1
AD06	GAIA General Design and Interface Requirements Specification (GDIR)	GAIA.ASF.SP.SAT.00002 Issue 1 Revision 4
AD07	SREM Interface Control Document	SREM-DI-CSAG-03 Issue 1 Revision 5
AD08	Gaia PacketWire Requirements	GAIA.ASU.IRD.ESM.00004 Issue Draft

2.1.2 Reference Documents

RD01		

2.1.3 Standards

SD01	SpaceWire - Links, nodes, routers and networks	ECSS-E-50-12A

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3 AVIONICS SCOE REQUIREMENTS

3.1 System Level Definition

AVI-4006/GSE-SYS-390/R

2 sets of Avionics SCOE shall be provided:

- *Set #1 for AVM.*
- *Set #2 for Spacecraft PVM AIT.*

AVI-4007/CREATED/R

*Both sets of Avionics SCOE shall be identical, with the exception that **only** Set #1 shall provide Power Simulation, as defined in Section 3.6.1 and Section 3.6.2.2.*

The Avionics SCOE comprises the following major items:

An Avionics SCOE Controller - see Section 3.2
Application Software with MMI - see Section 3.9
Instrumentation cards to fulfil each of the Spacecraft interface requirements - see Section 3.6
An interface with the Gaia Central Checkout System (CCS) - see Section 3.7
Interfaces to the Gaia Real Time Simulator (RTS), Star Tracker SCOE's and Dynamic FPA Simulator - see Section 3.8

AVI-210/CREATED/R

Where possible, the Instrumentation cards providing the Spacecraft and EGSE Interfaces shall be based on COTS products (i.e., VME, VXI, PXI, GPIB) or previously developed in-house systems.

AVI-221/CREATED/R

Instrumentation shall be provided by the Avionics SCOE to fulfil the following Spacecraft Interface and EGSE requirements, as detailed in the following sections:

Spacecraft Power Simulation (LCL/FCL) - Avionics SCOE Set #1 only
MIL-STD-1553B BUS Data Simulation, Acquisition and Spy (CDMU-SVM and CDMU-PLM BUS)
SpaceWire BUS Data Simulation, Acquisition and Spy (CDMU-EIU)
PacketWire BUS Data Simulation, Acquisition and Spy (CDMU-PDHS)
Combined CPS - command acquisition and status
Combined MPS - command acquisition, status and flow simulation
Pressure Transducer simulation (part of CPS and MPS)
Fine Sun Sensor HWIL Stimulation
Fine Sun Sensor Simulation
Gyro HWIL Stimulation
Standard High Power (SHP) command generation
Standard High Power (SHP) command acquisition
Alarm simulation
Bi-level TM Status simulation
Relay Status simulation
Analog Voltage simulation
Spacecraft Radiation Environmental Monitor (SREM) simulation
EGSE Synchronisation Pulse

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Figure 3.1-1 is a block diagram of the Avionics SCOE, illustrating its interfaces to the Gaia Spacecraft and other EGSE: (This diagram is indicative only, and is not intended to impose an implementation on the Avionics SCOE supplier)

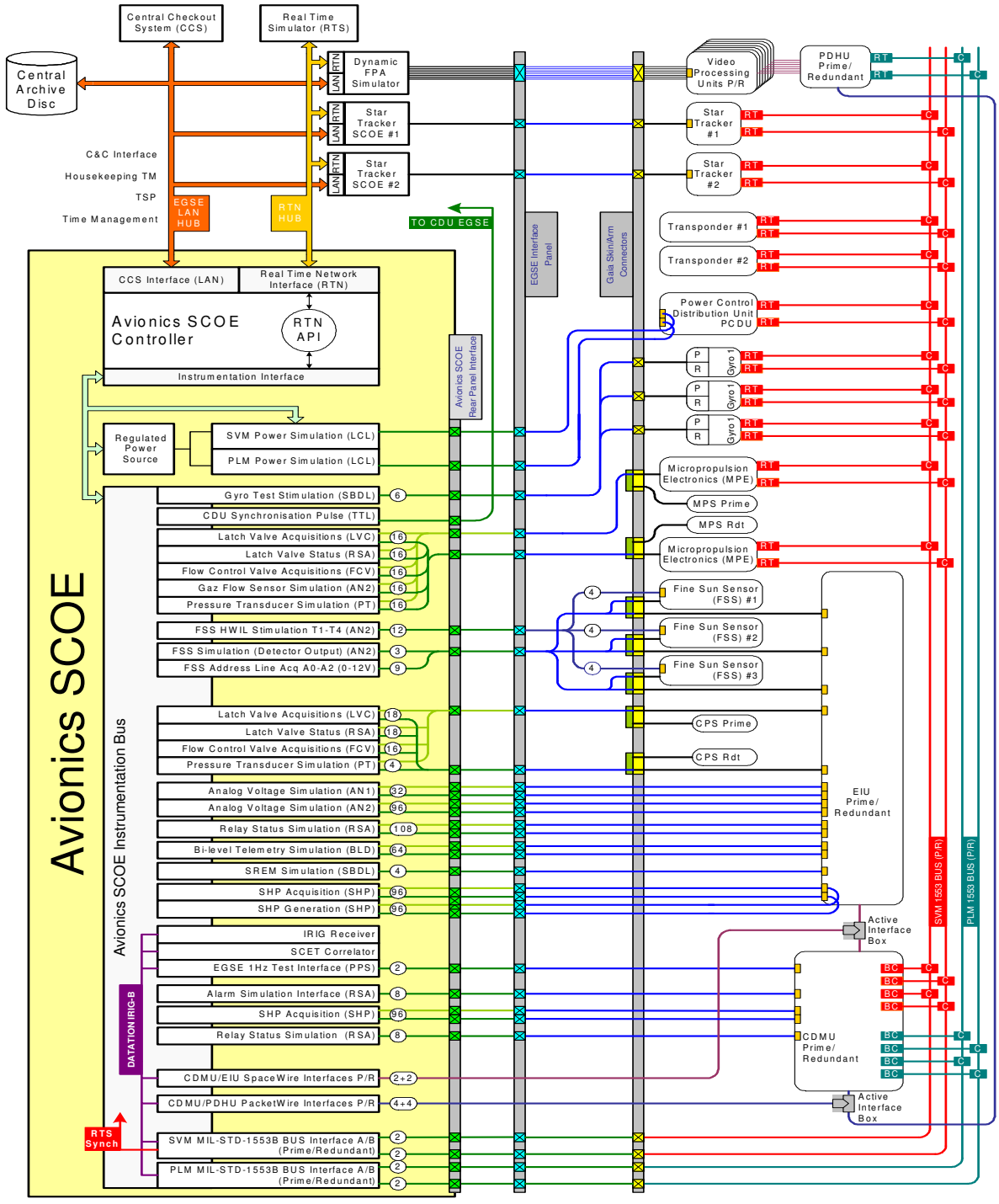

Figure 3.1-1: Avionics SCOE Block Diagram

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3.2 Avionics SCOE Controller

AVI-209/GSE-SYS-788/R

The Avionics SCOE Controller shall comprise a standard COTS Workstation Platform and Real Time Operating System (i.e., LINUX-RT, VxWorks or MicroSoft Windows-RT).

AVI-3061/GSE-SYS-772/I,R

The Avionics SCOE Controller Workstation shall be configured to the minimum specification given below:

Installed Memory (RAM):	2GB DDR2 ECC
Hard Disc Drive #1	100GB 7,200rpm
Hard Disc Drive #2	100GB 7,200rpm
Hard Disc Drive #3	500GB 7,200rpm
Display	19" LCD Flat Panel Monitor (DVI) 1280x1024 resolution
Graphics Controller	128MB Dual (DVI) - PCI-Express
Network Interface (CCS)	10M/100M/1000M Gigabit ETHERNET PCI-Express Network Interface Card Note: PCI-Express is required to achieve near-Gigabit performance
Real Time Network Interface (Reflective Memory)	As defined in Section 3.8
Optical Media:	16x DVD ±RW
Input Media:	Keyboard and Optical Mouse Device
Backup System:	DAT DDS5 backup tape system

AVI-211/CREATED/T

The Workstation platform processor shall be sized such that CPU average loading does not exceed 50% under any Avionics test configuration.

AVI-212/CREATED/I,R

The Avionics SCOE Controller Hard Disc Drives shall be utilized as follows:

- *Hard Disc Drive #1: RTOS installation.*
- *Hard Disc Drive #2: Avionics SCOE Application Software (installation, runtime files and IDE).*
- *Hard Disc Drive #3: Local Archive Disc.*

AVI-4238/GSE-SYS-773/T

Automated routines shall be provided to allow backup of the Avionics SCOE Controller Hard Disc Drives on a daily (delta) and weekly (complete) basis.

AVI-3102/CREATED/R

All Avionics SCOE Application Software files shall be placed under configuration control using a Configuration Management tool to defined by the supplier. These files to include, as a minimum:

- *Application Source Code*
- *Configuration Files*
- *Initialization Files*
- *Run Time Files*
- *Sequence Files*
- *Any tools provided as part of the Application*

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AVI-3115/CREATED/A

As a minimum, it shall be possible to run a Test Session on the Avionics SCOE for a period of 5 days, without loss of synchronisation or data.

AVI-4234/CREATED/T

It shall be possible to run a test session on the Avionics SCOE within 1 minute after boot of the Avionics SCOE Controller.

Note: This requirement does take account of any warm-up time which may be needed for the SCOE hardware equipments.

3.3 Avionics SCOE Grounding Requirements

AVI-1580/CREATED/R

The Avionics SCOE shall provide galvanic isolation between the Spacecraft Interfaces and the SCOE chassis/safety ground.

This may be achieved by a number of methods, including:

- Provision of isolated Power Supplies to the various Spacecraft Interface electronics.
- Choice of Spacecraft Interface circuits which are inherently isolated (relay contacts, optocouplers, etc.)

3.4 Avionics SCOE Test Modes

AVI-1589/GSE-SYS-391/T

The Avionics SCOE shall provide 3 Test Modes:

- *Local Test Mode.*
- *Remote Test Mode.*
- *Closed-Loop Test Mode.*

AVI-1590/CREATED/T

In Local Test Mode, data output to the Spacecraft Interfaces shall be determined initially by configuration file and updated by the operator under control of the local MMI. Data inputs from the Spacecraft Interfaces shall be acquired, archived locally and made available to the local MMI.

AVI-1591/GSE-SYS-392/T

In Remote Test Mode, data output to the Spacecraft Interfaces shall be determined initially by configuration file and can be updated by the CCS (Test Procedures). Data inputs from the Spacecraft Interfaces shall be acquired, made available to the local MMI and transferred to the CCS (Test Procedures).

AVI-1592/GSE-SYS-393/T

In Closed-Loop Test Mode, specific data output to the Spacecraft Interfaces shall be determined by the Real Time Simulator (RTS) and specific data inputs from the Spacecraft Interfaces transferred to the RTS.

AVI-3378/GSE-SYS-393/T

It shall be possible to operate in Closed-Loop Test Mode either locally, under control of the MMI, or remotely, under control of the CCS (as determined by the LOCAL/REMOTE state of the Avionics SCOE - see Section 3.9).

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3.5 Timing, Synchronisation and Acquisition Requirements

3.5.1 Time Synchronisation

The overall timing requirements for Gaia EGSE are described in Section 5 of the Gaia EGSE ICD [AD01].

AVI-2937/CREATED/T,R

The Avionics SCOE Controller local time shall provide a UTC reference time source (T_{REF}) to all other EGSE requiring synchronisation to it.

AVI-3391/CREATED/T,R

The source of T_{REF} shall be reference time with a granularity of better than 1us.

AVI-3390/CREATED/T

The Avionics SCOE shall provide IRIG-B time-coded signals to the 1553, SpaceWire and PacketWire BUS interface cards for time-stamping of internal spy acquisitions.

AVI-2939/CREATED/T

All Avionics SCOE data acquisitions shall be time-stamped with T_{REF}.

AVI-2948/CREATED/T,A

All data acquisition time-stamps of the Avionics SCOE shall be accurate to within 1us of T_{REF}, this including internal spy of the 1553 and SpaceWire cards.

AVI-3113/CREATED/T

The Avionics SCOE shall provide the Standard Network Time Protocol server function on the EGSE local LAN for time synchronisation of all Gaia EGSE connected to it.

3.5.2 Synchronisation

AVI-1653/GSE-SYS-396/I,R

The Avionics SCOE instrumentation platform shall be synchronized to an internal clock, with a stability better than 0.01 ppm ($1.0+E10^{-8}$)

AVI-1656/CREATED/T

The Avionics SCOE shall provide synchronisation to the Real Time Simulator, Dynamic FPA Simulator and Star Tracker SCOE's across the Real Time Network (RTN) - see Section 3.8.

AVI-1657/CREATED/T

The synchronisation shall be in the form of RTN global interrupts synchronized to the Major Frame and Minor Frame control cycles of the Gaia Central Software (CSW).

AVI-2835/CREATED/T

*Synchronisation to the CSW control cycle shall be achieved by detection of the Major Frame (1Hz) and Minor Frame (8Hz) synchronisation mode code transmissions at sub-addresses **TBC** and **TBC** respectively of the CDMU-SVM 1553 BUS.*

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3.5.3 Data Acquisition

AVI-2837/CREATED/T,R

Avionics SCOE data acquisition and data generation shall occur both synchronously and asynchronously.

AVI-2839/CREATED/T

All data inputs to the Avionics SCOE from the Spacecraft Interfaces shall be acquired asynchronously (such as pulses, address lines, bus acquisitions).

AVI-3547/CREATED/T

The acquisition of data inputs to the Avionics SCOE from the Spacecraft Interfaces shall be triggered by the data itself.

AVI-4228/CREATED/T

The acquisition of all data inputs to the Avionics SCOE shall be possible in parallel.

AVI-3548/CREATED/T

For transfer to the RTS (closed-loop test mode), the data inputs shall be buffered and collected synchronously by the RTS at the update rates defined in Appendix B, Table 11-1.

AVI-3546/CREATED/T

In closed-loop test mode, those outputs to the Spacecraft Interfaces controlled by the RTS shall be updated synchronously on completion of the DMA write cycle from the RTS (see Section 3.8.1).

AVI-3601/CREATED/T

The update rates for those outputs to the Spacecraft Interfaces controlled by the RTS shall be as defined in Appendix B, Table 11-1.

AVI-2849/CREATED/T

Asynchronous outputs to the Spacecraft Interfaces are data generated from asynchronous events - such as commands from the CCS, the Avionics SCOE Software control loops or MMI. Such data shall be updated and sent to the Spacecraft on demand.

AVI-3104/CREATED/T

All data both acquired and generated by the Avionics SCOE shall be:

- *transferred to the CCS for processing and central archive - see Section 3.9.3.*
- *available to the Avionics SCOE MMI for local display and/or adaptation - see Section 3.9.5.*
- *archived locally when connection to the CCS is lost.*

The data interface requirements between the Avionics SCOE and the Real Time Simulator are defined in the individual Spacecraft Interface sections and summarized in Appendix B, Section 11.

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3.5.4 SCET Correlation

The Gaia CDMU transmits Spacecraft Elapsed Time (SCET) using a SVM 1553 broadcast message at subaddress SA 29 (refer to Section 9.5 of [AD05]).

The CDMU (Telemetry Frame Generator) also inserts SCET in VC0 of each Telemetry Frame for transmission to the Ground System.

As the Gaia Central Checkout System (CCS) is the acquisition and archive media for Telemetry, it must correlate Telemetry reception with T_{REF}.

As the receptor of SVM 1553 BUS data and PPS, the Avionics SCOE will provide the means for the CCS to correlate SCET with T_{REF}.

AVI-1654/CDMU-836,CDMU-837/T

The Avionics SCOE shall receive 1Hz (PPS) synchronisation signals from the CDMU (both prime and redundant), in accordance with the following specification: [AD06] Section 3.5.5.1.3.1 (LVDS)

The SCET value broadcast by the CDMU is valid at the occurrence of the next rising edge of the CDMU 1Hz (PPS) signal.

AVI-2845/CREATED/T

The Avionics SCOE shall detect the 1553 SCET broadcast message and extract the SCET time.

AVI-2846/CREATED/T

On the occurrence of the next PPS, the Avionics SCOE shall latch the value of SCET and T_{REF}.

AVI-3371/CREATED/T

From (latched) T_{REF} the Avionics SCOE shall calculate the value of H_{REF}, where H_{REF} is 'the number of microseconds since the beginning of the current year' expressed as a 64 bit integer.

AVI-3392/CREATED/T

The value of T_{REF}, shall be accurate to <10us referenced to the rising edge of PPS.

AVI-2847/CREATED/T

When connected to the CCS, at intervals of PPS, the SCET/H_{REF} pair shall be transmitted to the CCS over the EGSE LAN using the format defined in Section 3.7.

AVI-3036/CREATED/T

The default CDMU PPS signal to be used for correlation shall be the Prime.

AVI-3038/CREATED/T

Selection between Prime and Redundant CDMU PPS correlation signals shall be available from the MMI or under the control of the CCS (Test Procedure).

AVI-3037/CREATED/T

In the case of loss of the selected CDMU PPS correlation signal, the Avionics SCOE shall automatically switch to the other.

AVI-3040/CREATED/T

In the case of reacquisition of the selected CDMU PPS correlation signal, the Avionics SCOE shall switch to it.

AVI-4229/CREATED/T

All acquisitions or re-acquisitions of the CDMU PPS shall be achieved within 2s (2 cycles of PPS).

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AVI-3041/CREATED/T

In the case of loss of both CDMU PPS correlation signals, the Avionics SCOE shall free-run the correlation function at one second intervals from the last latched value of T_{REF} and flag an error towards the operator (MMI).

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3.6 Spacecraft Interface Requirements

The Spacecraft Interfaces provide the hardware I/O with the Spacecraft. All I/O interfaces to the Spacecraft are summarized in Appendix A.

Individual I/O interfaces to the Spacecraft will be identified by unique Symbolic Name to be defined following project kick-off.

The Symbolic Naming convention is derived from the Spacecraft EICD and is used as a common interface definition for data transfer with the Real Time Simulator.

3.6.1 Spacecraft Power Simulation

The Gaia Spacecraft includes a Power Control and Distribution Unit (PCDU), which provides BUS power to all other Spacecraft units using individual Latching Current Limiter (LCL) and Foldback Current Limiter (FCL) modules, fed from a regulated power bus.

AVI-3043/CREATED/T

*The Avionics SCOE (**Set#1 only**) shall provide simulation of the PCDU LCL outputs to allow continued testing in the AVM Bench configuration when the PCDU may be missing.*

AVI-4061/CREATED/I,R

To fulfil the output impedance requirements for LCL simulation identified in AVI-4054 the Power Simulation facilities shall be provisioned in a separate rack for location close to the PCDU harness in the AVM configuration.

AVI-2474/CREATED/T

The Avionics SCOE shall provide the following representative LCL outputs:

Note: Numbers to be supplied are sufficient to power all Spacecraft Units (including redundancy and spares) during AVM bench testing. LCL outputs for heater control are not required.

LCL Type	Current Limit	Number
LCL Class A	1A	17
LCL Class B	2A	10
LCL Class C	3A	7
LCL Class D	5A	2
LCL Class E	8A	1
LCL Class F	10A	1
	Total	38

Table 3.6-1: LCL Quantities

AVI-4020/CREATED/R

The Avionics SCOE supplier shall consider 2 types of Power Simulation:

- ***Type 1**: Individual LCL output simulation provided by relay-switched and fused lines.*
- ***Type 2**: Individual LCL output simulation provided by simulation of the real Spacecraft LCL circuits.*

AVI-4236/CREATED/R

Type 1 Power Simulation shall be the included in the proposal baseline.

AVI-4237/CREATED/R

Type 2 Power Simulation shall be included as separately costed Option to the baseline proposal.

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AVI-4021/CREATED/T,R

For both Type 1 and Type 2 Power Simulation, the LCL outputs shall be fed from a common Power Source (or multiple sources feeding LCL groups).

Note: The common Power Source is equivalent to the PCDU Main Bus regulation point.

AVI-4022/CREATED/T

The common Power Source (or sources) shall meet the following specification:

Reqt		
-1	Output Voltage	28.0V ± 0.14V (±0.5%)
-2	Current Limit	+10% As defined in Table 3.6-1 for all or groups of LCL
-3	Over Voltage Protection Level	34.0V ±50mV
-4	Over Current Protection Level	+200mA ±50mA of overall Current Limit
-5	Protection Response Time	>5ms < 15ms (from protection occurrence)
-6	Output Ripple	<100mV

AVI-4054/CREATED/T

The output impedance of any single (simulated) LCL output shall be < 20mΩ, including the contribution of the cable connecting to the Spacecraft harness.

AVI-4055/CREATED/A,R

For Type 1 and Type 2 simulations, the Voltage Regulation point shall be the common Power Source.

AVI-2583/CREATED/T

In open-loop test modes, it shall be possible to switch ON/OFF LCL outputs by any of the following methods:

- *in response to commands received by the PCDU Remote Terminal of the 1553 BUS, as defined in Section 3.6.2.2.*
- *by detection of the relevant SHP command , as defined in Section 3.6.9.*
- *by command from the local MMI.*
- *remotely from the CCS (Test Procedure).*

AVI-4097/CREATED/T

Switch ON or OFF of LCL circuits by response to PCDU RT 1553 BUS commands and by SHP shall both be possible, depending on Gaia command distribution requirements.

AVI-4098/CREATED/T

Switch ON or OFF of LCL circuits by local MMI and remote CCS shall be available to override Spacecraft commanding for failure injection.

AVI-2584/CREATED/T

In closed-loop test mode, ON/OFF switching of the LCL circuits shall be achieved under the control of the RTS, in response to MIL-STD-1553B BUS or SHP commands received by the PCDU Model.

AVI-3439/CREATED/T

The protection status of each LCL output shall be made available to the operator (local MMI). Specifically, an error shall be raised if any protection circuit is triggered.

AVI-2750/CREATED/T

*It shall be possible to switch off **all** LCL output by single command from the local MMI or remotely from the CCS (Test Procedure).*

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AVI-4060/CREATED/T

*It shall be possible to switch off **all** LCL output by way of Emergency OFF switches, located on both the Avionics SCOE front panel and the Power Simulation rack front panel.*

AVI-2577/CREATED/T

Each LCL circuit shall provide a monitor circuit to measure output current to an accuracy of 3% (full scale).

AVI-2578/CREATED/T

LCL current measurements shall be acquired synchronously and made available to the RTS as inputs to the PCDU Model.

AVI-2579/CREATED/T

Each LCL circuit shall provide a monitor of its ON/OFF STATE.

AVI-2580/CREATED/T

LCL STATE shall be acquired synchronously and made available to the RTS as inputs to the PCDU Model.

3.6.1.1 Type 1 Power Simulation

AVI-4058/CREATED/T,R

Simulated LCL outputs shall be provided using Power Relay Switches to Fused lines.

AVI-4059/CREATED/T,R

The Power Relay Switches shall provide isolation on both the positive and negative lines.

AVI-4062/CREATED/I

Fuses for current protection shall be provided in accordance with the Current Limit requirements of Table 3.6-1 within a margin of +10%.

AVI-4063/CREATED/A,I

Fuses for current protection shall allow in-rush current above the current protection limits for a period of up to 10ms following switch on.

AVI-4064/CREATED/T

Fuses for current protection shall operate (blow) within 20ms of the simulated LCL output exceeding the current limit as specified in Table 3.6-1.

3.6.1.2 Type 2 Power Simulation

AVI-2527/CREATED/T,R

Type 2 Power Simulation shall be provided by individual LCL circuits conforming to the following specifications: [AD06] Table 3.5-2, Regulated BUS LCL Power Interface Characteristics (Source Circuit Specification).

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3.6.2 1553 BUS Interfaces

The Gaia on-board command/control system is based on a MIL-STD-1553B bus architecture.

Communications between the Control & Data Management Unit (CDMU) and the majority of the Service Module (SVM) units and Payload Module (PLM) units are performed via two (2) MIL-STD-1553B buses:

- a dual-redundant MIL-STD-1553B bus dedicated to the communications with the SVM
- a dual-redundant MIL-STD-1553B bus dedicated to the communications with the PLM

For each bus, the CDMU is the Bus Controller.

AVI-259/CDMU-745,GSE-SYS-409/T

Separate MIL-STD-1553B BUS Interfaces shall be provided to simulate the Spacecraft Service Module (SVM) and Payload Module (PLM) BUS.

AVI-260/CREATED/T,R

Each 1553 BUS Interface shall provide the following services:

Redundant Bus Operation (BUSA/BUSB)
Remote Terminal (RT) Functions - for up to 31 RTs
Bus Monitor Functions (Bus Spy)

AVI-274/CREATED/T

The 1553 BUS Interface cards shall be configured and controlled by the Avionics SCOE, or by the RTS for closed-loop Avionics testing.

AVI-275/CREATED/R

The 1553 BUS Interface cards shall be based on COTS or previously developed in-house systems.

AVI-291/CREATED/R

The 1553 BUS Interface cards (specifications, configuration and Remote Terminal addressing) shall conform to [AD05].

AVI-710/GSE-SYS-399, GSE-SYS-401, CSE-SYS-406, GSE-SYS-407, GSE-SYS-408/T

Data simulation and acquisition shall be provided for each of the following RT:

SVM 1553 Bus	PLM 1553 Bus
PCDU A	CDU #1
STR #1	PDHU A
TRSP #1	MDE #1
MPE #1	OSE #1
GYRO #1A	VPU #1
GYRO #1B	VPU #2
GYRO #1C	VPU #3
PAA #1A	VPU #4
PCDU B	VPU #5
STR #2	VPU #6
TRSP #2	VPU #7
MPE #2	CDU #2
GYRO #2A	PDHU B
GYRO #2B	MDE #2
GYRO #2C	OSE #2
PAA #1B	

AVI-375/CREATED/T

The Avionics SCOE shall provide decommutation of the 1553 BUS data for parameter acquisition of each RT.

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AVI-702/CREATED/T

The Avionics SCOE shall provide simulation of data for each RT on the 1553 BUS to simulate missing Spacecraft units.

AVI-3293/GSE-SYS-749, GSE-SYS-752, GSE-SYS-759, GSE-SYS-763, GSE-SYS-764, GSE-SYS-765/T

For each RT on the 1553 BUS, Prime and Redundant BUS operation shall be possible in parallel.

AVI-1899/CREATED/T

In open-loop test modes, simulation of the each RT shall be as fixed responders only.

AVI-4105/CREATED/T

In open-loop test modes, RT response data for BUS commands shall be defined by input file, direct user input at the local MMI or by definition from the CCS (Test Procedure/Command Line).

The input file for default 1553 BUS responses will be supplied by Astrium Ltd., in a human-readable file format (such as XML) as agreed between Astrium Ltd and the Avionics SCOE subcontractor.

The input file will identify, as a minimum, the response data by:

- BUS (A/B)
- Remote Terminal (RT)
- Subaddress (SA)
- Symbolic Name
- Data Size (Word Count)
- Default Value

AVI-4077/CREATED/T

In open-loop test modes, the user shall be able to update the 1553 data response values from the local MMI or CCS (Test Procedure) by specifying:

- *RT and SA, or*
- *Symbolic Name*

AVI-704/CREATED/T

In closed-loop test mode, the RTS shall receive BUS data and respond on the 1553 BUS.

AVI-3157/CREATED/T

In closed-loop test mode, local decommutation of BUS data shall be possible in parallel to RTS operation.

AVI-2854/CREATED/T

For each 1553 BUS, the Avionics SCOE shall implement a 1553 BUS SPY function, configurable by RT, which shall capture all traffic of the BUS and store in local files.

Where appropriate, the 1553 BUS SPY function may be achieved using COTS software provided with the 1553 cards.

AVI-2856/CREATED/T

A BUS ANALYSER tool shall be provided to allow the operator to view and analyse the BUS traffic in real time.

AVI-2857/CREATED/T

The BUS ANALYSER tool shall also allow analysis of BUS traffic previously stored in local files.

Where appropriate, the BUS ANALYSER function may be achieved using COTS software provided with the 1553 cards.

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AVI-2865/CREATED/T

It shall be possible to enable/disable the 1553 BUS SPY function at any time from the local MMI or by command from the CCS.

AVI-1897/CREATED/T

Configuration of the BUS shall be possible from the local MMI, from the CCS (Test Procedure) or from the RTS.

AVI-3116/CREATED/T

The following configuration options shall be available for each RT of the 1553 BUS:

Command:	**Comment:**
INITIALISE RT	Reset RT, RT Disabled, Spy OFF
DISABLE RT	RT Disabled, Spy OFF, SA configuration maintained
ENABLE RT	RT Enabled, Spy OFF, all SA enabled
ENABLE SA	Enable SA on specified RT (RT must be enabled)
DISABLE SA	Disable SA on specified RT (RT must be enabled)
ENABLE SPY	Spy ON (RT may be disabled)
DISABLE SPY	Spy OFF
ENABLE PASSIVE[1]	RT Enabled, but does not respond on the BUS
DISABLE PASSIVE[1]	RT Disabled
SET ERROR n	Set specified ERROR on RT

Note[1]: The purpose of PASSIVE mode operation on the 1553 BUS is to allow Models of the RTS to operate in parallel with real Spacecraft Units without responding to commands on the BUS.

AVI-3117/CREATED/T

As a minimum, it shall be possible to set the following errors on any RT of the 1553 BUS:

- *No response on the RT*
- *Parity error*
- *Word Count error*
- *All error bits of the Status Word*

AVI-3152/CREATED/T

It shall be possible to set transient and permanent errors for each RT.

3.6.2.1 1553 BUS Spy Extraction Tool

AVI-3153/CREATED/T

A tool shall be provided to allow data previously stored in 1553 BUS Spy files to be extracted to a file or displayed in a viewer.

AVI-4070/CREATED/T

For file output, a file header shall be inserted giving the following information:

- *File name from which the extraction is performed.*
- *Extraction date.*
- *The Extraction options selected.*

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AVI-3154/CREATED/T

The extraction tool shall allow data extraction by use of one or a combination of the following single or multiple filters:

- *Range [extract data between a specified datation range]*
- *Message [extract data between a range of specified messages]*
- *RT [extract data for a specific or multiple of RT]*
- *SA [extract data for a specific or multiple SA of a specified RT]*
- *Symbolic Name [in accordance with the input files specified - see AVI-4075]*
- *Error [extract errors only]*
- *"RES" file dump.*

AVI-3155/CREATED/T

The extraction tool shall provide data in the following format:

<number> <time> <direction> <RT> <SA> <length> <CW> <BUS> <SW> <DW1> ... <DWn> <status>

Where:

<number>	*- is the message number*
<time>	*- is the datation of the data in IRIG-B format to 1us precision*
<direction>	*- is the direction of the message BC→ or BC←*
<RT>	*- RT is the Remote Terminal address RT[00] to RT[31]*
<SA>	*- SA is the RT subaddress SA[00] to SA[31]*
<length> LEN[32]	*- is the number of Data Words contained in the message LEN[01] to*
<CW>	*- is the message Control Word CW[$XXXX_{HEX}$]*
<BUS>	*- is BUS[A] (nominal) or BUS[B] (redundant)*
<SW>	*- is the message Status Word SW[$XXXX_{HEX}$]*
<DW1> ... <DWn>	*- is the message Data Words DW[$XXXX_{HEX}$] ... DW[$XXXX_{HEX}$]*
<status>	*- is the message status [OK] or [error message]*

AVI-4137/CREATED/T

If the '"RES" file dump' filter option is selected (see AVI-3154), the requested data (by Symbolic Name) shall be stored in a separate file using the "RES" file format, as defined in [AD01] Section 7.

AVI-4138/CREATED/T

In accordance with the "RES" file format, the data time stamps (relevant to each data extraction) shall be added to the file as the first data parameter.

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3.6.2.2 PCDU Remote Terminal 1553 BUS Interface

This section only applies to Avionics SCOE Set #1 for Power Simulation requirements.

One special case of MIL-STD-1553B Remote Terminal simulation is that of the PCDU.

When simulation of the PCDU is required, some LCL circuits are simulated in hardware by the Avionics SCOE (see Section 3.6.1 - Spacecraft Power Simulation).

Note: The need for LCL simulation in hardware is determined by the current Spacecraft configuration (which Spacecraft Units are HWIL).

AVI-2565/CREATED/T

For those LCL circuits designated for hardware simulation, their state (ON/ OFF) shall be controlled by the corresponding ON/OFF commands received by the PCDU RT.

AVI-2567/CREATED/T

In all test modes, the local Application Software shall decode the 1553 BUS commands and switch ON/OFF, as directed, the corresponding LCL circuit.

AVI-2568/CREATED/T

In closed-loop test mode, the RTS shall directly control the state of the LCL circuits in response to the PCDU 1553 BUS commands.

AVI-2569/CREATED/T

For those LCL designated for hardware simulation, their status (ON/OFF) and output currents shall be read from the corresponding LCL circuits.

AVI-2570/CREATED/T

In open-loop test modes, the local Application Software shall read the STATE and currents for those LCL circuits simulated in hardware and send that data on the 1553 BUS as requested.

AVI-2571/CREATED/T

In closed-loop test mode, STATE and currents of the simulated LCL circuits shall be available to the RTS for insertion in the 1553 BUS response.

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3.6.3 SpaceWire BUS Interfaces

AVI-277/EIU-2313,CDMU-3391,GSE-SYS-397/T

Interfaces shall be provided for the Spacecraft CDMU/EIU (2) SpaceWire BUS.

AVI-278/GSE-SYS-397/T

Each Interface shall provide the following services:

Redundant Bus Operation (A/B)
Bus Monitor Functions (Bus Spy)

AVI-288/EIU-2315,CDMU-3393/T

It shall be possible to operate the CDMU/EIU SpaceWire BUS data rates up to 10Mbs.

AVI-2767/CREATED/T

The SpaceWire BUS Interface cards shall be configured and controlled by the Avionics SCOE, or by direct interface to the RTS for closed-loop Avionics testing.

AVI-289/CREATED/R

The SpaceWire BUS Interface cards shall be based on COTS or previously developed in-house systems (where possible).

AVI-290/CDMU-3395/T,A

The SpaceWire BUS Interface Specification shall be as detailed in [AD05] Section 3.5.5.1.

AVI-376/CREATED/T

The Avionics SCOE shall provide decommutation of the SpaceWire BUS data for parameter acquisition of each BUS.

AVI-3475/GSE-SYS-748/T

For each SpaceWire BUS, data acquisition and data generation shall be possible in parallel.

AVI-4239/GSE-SYS-747/T

For each SpaceWire BUS, Prime and Redundant BUS operation shall be possible in parallel.

AVI-2850/CREATED/T

The Avionics SCOE shall provide data simulation for each SpaceWire BUS.

AVI-1901/CREATED/T

It shall be possible to configure SpaceWire BUS operation from the local MMI, by definition from the CCS (Test Procedure/Command Line) or from the RTS.

AVI-3440/CREATED/T

The following configuration options shall be available for each SpaceWire BUS:

Command:	Comment
INITIALISE	Reset, Disabled, Spy OFF
DISABLE	Disabled, Spy OFF
ENABLE	Enabled, Spy OFF
ENABLE SPY	Spy ON (BUS may be disabled)
DISABLE SPY	Spy OFF
ENABLE PASSIVE[2]	Enabled, but does not respond on the BUS
DISABLE PASSIVE[2]	Disabled
SET ERROR n	Set specified ERROR on SpaceWire BUS

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Note[2]: The purpose of PASSIVE mode operation on the SpaceWire BUS is to allow Models of the RTS to operate in parallel with real Spacecraft Units without responding to commands on the BUS.

AVI-705/CREATED/T

In open-loop test modes, simulation of the each SpaceWire BUS shall be as fixed responders only.

AVI-4107/CREATED/T

In open-loop test modes, SpaceWire responder data shall be defined by local input file, direct user input at the local MMI or by definition from the CCS (Test Procedure/Command Line).

The input file for default SpaceWire BUS response will be supplied by Astrium Ltd., in a human-readable file format (such as XML) as agreed between Astrium Ltd and the Avionics SCOE subcontractor.

The input file will identify, as a minimum, the response data by:

- BUS Number (1 or 2)
- BUS Side (A/B)
- Command
- Symbolic Name
- Data Type
- Default Value

AVI-4101/CREATED/T

In open-loop test modes, the user shall be able to update the SpaceWire data response values from the local MMI or CCS (Test Procedure) by specifying the Symbolic Name and data value.

AVI-706/CREATED/T

In closed-loop test mode, the RTS shall directly respond to the SpaceWire BUS (acquisition and data simulation).

AVI-2860/CREATED/T

For each SpaceWire BUS, the Avionics SCOE shall implement a SpaceWire BUS SPY function which shall capture all traffic of the BUS and store in local files.

Where appropriate, the SpaceWire BUS SPY function may be achieved using COTS software provided with the SpaceWire cards.

AVI-2862/CREATED/T

A BUS ANALYSER tool shall be provided to allow the operator to view and analyse the SpaceWire BUS traffic in real time.

AVI-2863/CREATED/T

The BUS ANALYSER tool shall also allow analysis of SpaceWire BUS traffic previously stored in local files.

Where appropriate, the BUS ANALYSER function may be achieved using COTS software provided with the SpaceWire cards.

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3.6.3.1 SpaceWire BUS Spy Extraction Tool

AVI-3550/CREATED/T

A tool shall be provided to allow data previously stored in SpaceWire BUS Spy files to be extracted to files or displayed in a viewer.

AVI-4073/CREATED/T

For file output, a file header shall be inserted giving the following information:

- *File name from which the extraction is performed.*
- *Extraction date.*
- *The Extraction options selected.*

AVI-3551/CREATED/T

The extraction tool shall allow data extraction by use of one or a combination of the following single or multiple filters:

- *Range [extract data between a specified datation range]*
- *Message [extract data between a range of specified messages]*
- *Symbolic Name [in accordance with the input files specified - see AVI-4099]*
- *Error [extract errors only]*
- *"RES" file dump.*

AVI-3552/CREATED/T

The extraction tool shall provide data in the following format: (to file or viewer)

<number> <time> <direction> <BUS> <DATA> <status>

Where:

<number>	*- is the message number*
<time>	*- is the datation of the data in IRIG-B format to 1us precision*
<direction>	*- is the direction of the message CDMU→ or CDMU←*
<BUS>	*- is BUS[A] (nominal) or BUS[B] (redundant)*
<DATA>	*- is the message Data*
<status>	*- is the message status [OK] or [error message]*

AVI-4133/CREATED/T

If the '"RES" file dump' filter option is selected (see AVI-3551), the requested data (by Symbolic Name) shall be stored in a separate file using the "RES" file format, as defined in [AD01] Section 7.

AVI-4134/CREATED/T

In accordance with the "RES" file format, the data time stamps (relevant to each data extraction) shall be added to the file as the first data parameter.

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3.6.3.2 EIU SpaceWire SHP Interfaces

One special case of SpaceWire BUS simulation is that of the EIU for Standard High Power (SHP) Pulse Commands.

When simulation of the EIU is required, the Avionics SCOE simulates SHP generation in hardware (see Section 3.6.9 - SHP Pulse Command Generation) to allow switching of Spacecraft Units.

AVI-2757/CREATED/T

In all test modes, the local Application Software shall decode the EIU SpaceWire BUS commands and generate the SHP Pulses in hardware for SHP BUS commands.

Those CDMU-EIU SpaceWire commands related to SHP generation will be identified by Astrium Ltd in the SpaceWire responder input file to be provided, as defined in AVI-4099.

3.6.3.3 SpaceWire Active Interface

To allow the Avionics SCOE to SPY the SpaceWire BUS interfaces when the real CDMU and EIU are connected, an active interface is needed to allow the Avionics SCOE to monitor the SpaceWire traffic without disturbing normal BUS operation.

AVI-4112/CREATED/

An Active Interface Box shall be provided for each SpaceWire BUS to allow monitoring of the BUS when the CDMU and EIU units are connected.

Each Active Interface Box is connected between the Gaia CDMU and the EIU, as shown in Figure 3.6-1.

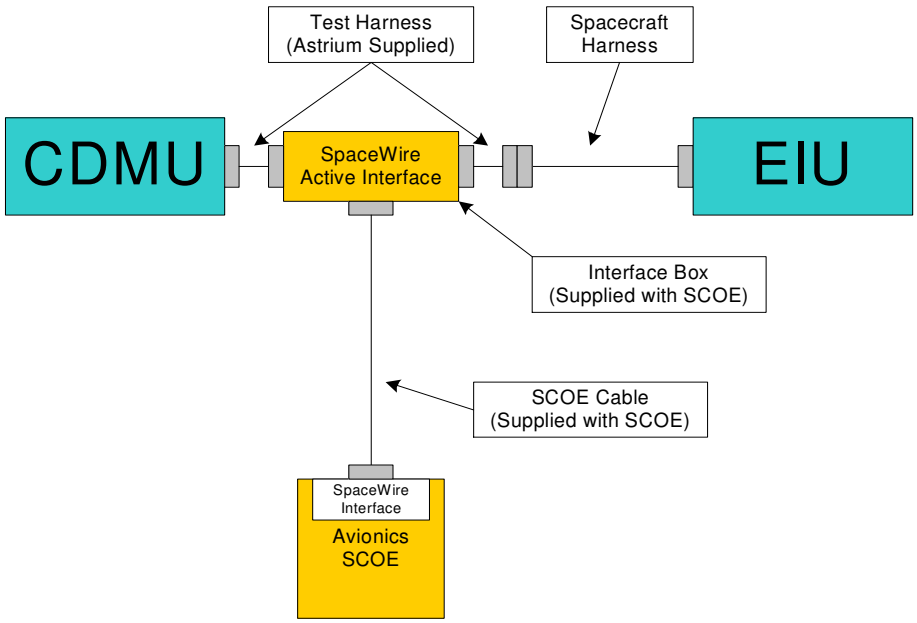

Figure 3.6-1: SpaceWire Active Interface Box

AVI-4124/CREATED/

The design of the Active Interface Box shall be such that SPY of both the prime and redundant side of each SpaceWire BUS is possible in parallel.

AVI-4125/CREATED/

The design of the Active Interface Box shall be such that the SpaceWire interface requirements, as defined in [AD05] Section 3.5.5.1 shall be maintained.

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3.6.4 PacketWire BUS Interfaces

AVI-3476/CDMU-3941/T

Interfaces shall be provided for the Spacecraft CDMU/PDHU (4) PacketWire (PW) BUS.

AVI-3477/GSE-SYS-397/T

Each Interface shall provide the following services:

Redundant Bus Operation (A/B)
Bus Monitor Functions (Bus Spy)

AVI-3483/CDMU-3943/T

The PW Interface signalling rate shall operate to a maximum of 10 Mbps.

AVI-3530/CDMU-3449/T

The PW Interface shall withstand a data throughput from the PLM of 2000 packets/second with a packet size varying from 300 bytes to 32 Kbytes.

AVI-3531/CDMU-3947/T,R

The PW Interface shall be implemented in accordance with the requirements of AD08.

AVI-3485/CREATED/T

The PW BUS Interface cards shall be configured and controlled by the Avionics SCOE, or by direct interface to the RTS for closed-loop Avionics testing.

AVI-3486/CREATED/R

The PW BUS Interface cards shall be based on COTS or previously developed in-house systems (where possible).

AVI-3488/CREATED/T

The Avionics SCOE shall provide decommutation of the PW BUS data for parameter acquisition of each BUS.

AVI-3489/CREATED/T

For each PW BUS, Prime and Redundant BUS operation shall be possible in parallel.

AVI-3490/CREATED/T

The Avionics SCOE shall provide data simulation for each PW BUS.

AVI-3491/CREATED/T

It shall be possible to configure PW BUS operation from the local MMI, by definition from the CCS (Test Procedure/Command Line) or from the RTS.

AVI-3492/CREATED/T

The following configuration options shall be available for each PW BUS:

Command:	Comment
INITIALISE	Reset, Disabled, Spy OFF
DISABLE	Disabled, Spy OFF
ENABLE	Enabled, Spy OFF
ENABLE SPY	Spy ON (BUS may be disabled)
DISABLE SPY	Spy OFF
ENABLE PASSIVE[3]	Enabled, but does not respond on the BUS
DISABLE PASSIVE[3]	Disabled
SET ERROR n	Set specified ERROR on SpaceWire BUS

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Note[3]: The purpose of PASSIVE mode operation on the PW BUS is to allow Models of the RTS to operate in parallel with real Spacecraft Units without responding to commands on the BUS.

AVI-3521/CREATED/T

In open-loop test modes, simulation of the each PacketWire BUS shall be as fixed responders only.

AVI-4108/CREATED/T

In open-loop test modes, PW response data shall be defined by local input file, direct user input at the local MMI or by definition from the CCS (Test Procedure/Command Line).

The input file for default PW BUS response will be supplied by Astrium Ltd., in a human-readable file format (such as XML) as agreed between Astrium Ltd and the Avionics SCOE subcontractor.

The input file will identify, as a minimum, the response data by:

- BUS Number (1 - 4)
- BUS Side (A/B)
- Command
- Symbolic Name
- Data Type
- Default Value

AVI-4104/CREATED/T

In open-loop test modes, the user shall be able to update the SpaceWire data response values from the local MMI or CCS (Test Procedure) by specifying the Symbolic Name and data value.

AVI-3522/CREATED/T

In closed-loop test mode, the RTS shall directly respond to the PW BUS (acquisition and data simulation).

AVI-3523/CREATED/T

For each PW BUS, the Avionics SCOE shall implement a PW BUS SPY function which shall capture all traffic of the BUS and store in local files.

Where appropriate, the PW BUS SPY function may be achieved using COTS software provided with the PW cards.

AVI-3525/CREATED/T

A BUS ANALYSER tool shall be provided to allow the operator to view and analyse the PW BUS traffic in real time.

AVI-3526/CREATED/T

The BUS ANALYSER tool shall also allow analysis of PW BUS traffic previously stored in local files.

Where appropriate, the BUS ANALYSER function may be achieved using COTS software provided with the PW cards.

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3.6.4.1 PacketWire BUS Spy Extraction Tool

AVI-4078/CREATED/T

A tool shall be provided to allow data previously stored in PW BUS Spy files to be extracted to a file or displayed in a viewer.

AVI-4079/CREATED/T

For file output, a file header shall be inserted giving the following information:

- *File name from which the extraction is performed.*
- *Extraction date.*
- *The Extraction options selected.*

AVI-4080/CREATED/T

The extraction tool shall allow data extraction by use of one or a combination of the following single or multiple filters:

- *Range [extract data between a specified datation range]*
- *Message [extract data between a range of specified messages]*
- *Symbolic Name [in accordance with the input files specified - see AVI-4102]*
- *Error [extract errors only]*
- *"RES" file dump.*

AVI-4081/CREATED/T

The extraction tool shall provide data in the following format:

<number> <time> <BUS> <DATA> <status>

Where:

<number>	*- is the message number*
<time>	*- is the datation of the data in IRIG-B format to 1us precision*
<BUS>	*- is BUS[A] (nominal) or BUS[B] (redundant)*
<DATA>	*- is the message Data*
<status>	*- is the message status [OK] or [error message]*

AVI-4135/CREATED/T

If the '"RES" file dump' filter option is selected (see AVI-4080), the requested data (by Symbolic Name) shall be stored in a separate file using the "RES" file format, as defined in [AD01] Section 7.

AVI-4136/CREATED/T

In accordance with the "RES" file format, the data time stamps (relevant to each data extraction) shall be added to the file as the first data parameter.

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3.6.4.2 PacketWire Active Interface

To allow the Avionics SCOE to SPY the PacketWire BUS interfaces when the real CDMU and PDHU are connected, an active interface is needed to allow the Avionics SCOE to monitor the PacketWire traffic without disturbing normal BUS operation.

AVI-4129/CREATED/T

An Active Interface Box shall be provided for each PacketWire BUS to allow monitoring of the BUS when the CDMU and PDHU units are connected.

Each Active Interface Box is connected between the Gaia CDMU and the PDHU, as shown in Figure 3.6-2.

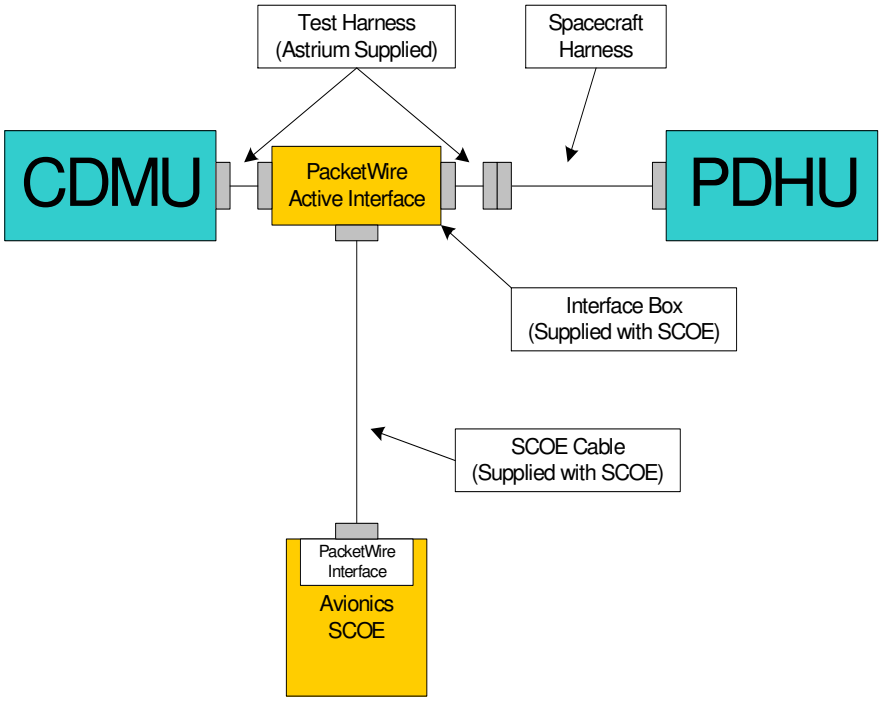

Figure 3.6-2: PacketWire Active Interface Box

AVI-4131/CREATED/T

The design of the Active Interface Box shall be such that SPY of both the prime and redundant side of each PacketWire BUS is possible in parallel.

AVI-4132/CREATED/T

The design of the Active Interface Box shall be such that the PacketWire interface requirements, as defined in [AD08] shall be maintained.

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3.6.5 Combined CPS Interfaces

The Gaia Combined CPS subsystem is controlled and monitored by the Spacecraft Electrical Interface Unit (EIU) and comprises:

18 x Latch Valves (LV) operating in (9+9) cold redundancy: (8+8) for the Thruster lines, (1+1) for the Tanks
18 x Latch Valves status micro-switches operating in (10+10) cold redundancy
16 x Flow Control Valves operating in (8+8) cold redundancy to control 2 banks of (8+8) 10N Thrusters
4 x Pressure Transducers for Tank Pressure monitoring

AVI-311/GSE-SYS-405/T

The Avionics SCOE shall provide interfaces to the EIU to simulate the presence of the Combined CPS subsystem.

AVI-295/EIU-701,EIU-702/T

The CPS Interfaces shall comprise the following functions.

LV Command Pulse Acquisition (18 LV, 1 x OPEN and 1 x CLOSED commands per Latch Valve)
LV Status Simulation (1 micro-switch simulation per Latch Valve)
FCV Command Pulse Acquisition (16 FCV)
4 x Pressure Transducer Simulations

3.6.5.1 CPS LV Command Pulse Acquisition

AVI-327/EIU-706/T

The LV Command Pulse Acquisition interface shall be provided by fixed loads (36x) simulating the OPEN and CLOSE coils for each of 18 LV.

AVI-328/EIU-706/T

LV Command Acquisition interface shall conform to the following specifications: [AD06] Table 3.5-35 (Latch Valve Interface Specification - Receiver Circuit Specification).

AVI-382/GSE-SYS-405/T

LV Command Pulse Acquisition shall provide Latch Valve state (OPEN/CLOSE) and measurement of the Command pulse width, as detailed below:

Pulse WIDTH resolution	100.0 µs - for nominal 50-100ms pulse
Latch Valve STATE	OPEN = acquisition of a 'valid' pulse on the corresponding LV OPEN coil CLOSED = acquisition of a 'valid' pulse on the corresponding LV CLOSE coil A 'valid' pulse shall be as defined in [AD06] Table 3.5-35.

Table 3.6-2: CPS - LV Command Pulse Measurement Specification

AVI-1886/CREATED/T

Measurement of LV Command pulses shall be triggered asynchronously by detection of an incoming pulse with the following specifications:

- *Pulse Width > 1ms*
- *Pulse Amplitude > 10.0V*

AVI-389/CREATED/T

LV STATE (OPEN/CLOSE) shall be made available to the RTS.

AVI-2768/EIU-3393, GSE-SYS-761/T

It shall be possible to acquire the LV pulses simultaneously on all channels.

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3.6.5.2 CPS LV Status Simulation

AVI-346/CREATED/T

LV Status Simulation function shall be provided by relay simulation (18x) of each LV STATUS micro-switch.

AVI-347/CREATED/T

LV Status Simulation shall conform to the following specifications: [AD06] Table 3.5-28 (Relay Status Acquisition Source Specification).

AVI-348/CREATED/T

In open-loop test modes LV STATUS (OPEN/CLOSE) relay shall be set to the STATE value of the corresponding LV command pulse acquisition (see AVI-382).

AVI-1609/CREATED/T

In open-loop test modes, it shall be possible to overwrite the LV STATUS from the local MMI or from the CCS (Test Procedure/Command Line).

Note: This allows error injection into the EIU - Latch Valve Status not reflecting the commanded operation.

AVI-1608/CREATED/T

In closed-loop test mode, LV STATUS shall be defined by the RTS.

3.6.5.3 CPS FCV Command Pulse Acquisition

AVI-359/EIU-713/T

The FCV Command Pulse Acquisition interface shall be provided by fixed loads (16x) simulating each of the FCV coils.

AVI-360/EIU-715/T

The FCV Command Acquisition interface shall conform to the following specifications: [AD06] Table 3.5-36 (Flow Control Valve Interface Specification - Receiver Circuit Specification).

AVI-378/CREATED/T

*FCV Command Pulse Acquisition shall provide measurements of the **integrated** ON time for each FCV, the individual command pulse widths and an event count per FCV, as detailed below:*

EVENT COUNT limit	65536
ON time resolution	5 %
Pulse WIDTH resolution	100.0 µs - for pulse widths 5ms to continuous

Table 3.6-3: CPS - FCV Command Pulse Measurement Specification

AVI-372/CREATED/T

*Once an FCV Command has triggered, ON time measurements shall be integrated every 15.625 ms (equivalent to the RTS Simulation Cycle rate of 1/64 of the Major Frame rate) and calculated as percentage (ON) over the integration period. **TBC***

Note: Although the CPS Model in the RTS executes at 64Hz in real-time, thrust vectors output to the Dynamics Model need to consider thruster pulses to an accuracy of <1ms.

AVI-1887/CREATED/T

Measurement of LV Command pulses shall be triggered asynchronously by detection of an incoming pulse with the following specifications:

- *Pulse Width > 1ms*
- *Pulse Amplitude > 10.0V*

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AVI-391/CREATED/T

It shall be possible to reset the event counters, individually or all at once, by command from the local MMI or from the CCS (Test Procedure/Command Line)..

AVI-390/CREATED/T

FCV ON times shall be made available to the RTS for closed-loop testing.

AVI-2769/EIU-713, GSE-SYS-761/T

It shall be possible to acquire the FCV pulses simultaneously on all channels.

3.6.5.4 CPS Pressure Transducer Simulation

AVI-427/EIU-734/T

The CPS Pressure Transducer Simulation shall simulate the presence of 4 Pressure Transducers.

AVI-463/EIU-735/T

CPS Pressure Transducer Simulation shall conform to the requirements of: [AD06] Table 3.5-12 (Analog Driver Specification 3)

AVI-432/CREATED/T

In open-loop test mode Simulated Pressures shall be commanded asynchronously by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1610/CREATED/T

In closed-loop test mode Simulated Pressures shall be commanded by the RTS.

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3.6.6 Combined Micropropulsion (MPS) Interfaces

The following requirements will be considered as **TBC** pending Micropropulsion supplier selection. The requirements given are indicative of the interfaces and necessary functionality to be provided.

The Gaia Combined MPS subsystem is controlled and monitored by the Spacecraft Micropropulsion Electronics unit (MPE) and comprises:

2 x Micropropulsion Electronics (MPE) units in (1+1) cold redundancy, providing the control and monitoring of:
• 16 x Latch Valves (LV) operating in (8+8) cold redundancy
• 16 x Latch Valves status micro-switches operating in (8+8) cold redundancy
• 16 x Flow Control Valves operating in (8+8) cold redundancy to control 2 banks of (8+8) Microthrusters
• 16 x Gas Flow Monitoring (GFM) sensors operating in (8+8) cold redundancy to measure flow through 2 banks of (8+8) Microthrusters for closed-loop control
• 16 x Pressure Transducers operating in (8+8) cold redundancy for Regulated Pressure monitoring

AVI-503/CREATED/T

The Avionics SCOE shall provide interfaces to the MPE to simulate the presence of the MPS subsystem components.

AVI-504/GSE-SYS-735/T

The MPS Interfaces shall comprise the following functions.

LV Command Pulse Acquisition (16 LV, 1 x ON and 1 x OFF commands per Latch Valve)
LV Status Simulation (1 micro-switch simulation per Latch Valve)
FCV Command Pulse Acquisition (16 FCV)
FCV Gas Flow Monitoring Sensor Simulation (16 Sensors)
16 x Pressure Transducer Simulations

3.6.6.1 MPS LV Command Pulse Acquisition

AVI-3558/EIU-706, GSE-SYS-737/T

The MPS LV Command Pulse Acquisition interface shall be provided by fixed loads (32x) simulating the OPEN and CLOSE coils for each of 16 LV.

AVI-3559/EIU-706, GSE-SYS-737/T

LV Command Acquisition interface shall conform to the following specifications: [AD06] Table 3.5-35 (Latch Valve Interface Specification - Receiver Circuit Specification).

AVI-3560/GSE-SYS-737/T

LV Command Pulse Acquisition shall provide Latch Valve state (OPEN/CLOSE) and measurement of the Command pulse width, as detailed below:

Pulse WIDTH resolution	100.0 µs - for nominal 50-100ms pulse
Latch Valve STATE	OPEN = acquisition of a 'valid' pulse on the corresponding LV OPEN coil CLOSED = acquisition of a 'valid' pulse on the corresponding LV CLOSE coil A 'valid' pulse shall be as defined in [AD06] Table 3.5-35.

Table 3.6-4: MPS - LV Command Pulse Measurement Specification

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AVI-3569/CREATED/T

Measurement of LV Command pulses shall be triggered asynchronously by detection of an incoming pulse with the following specifications:

- *Pulse Width > 1ms*
- *Pulse Amplitude > 10.0V*

AVI-3570/CREATED/T

LV STATE (OPEN/CLOSE) shall be made available to the RTS.

AVI-3571/GSE-SYS-754/T

It shall be possible to acquire the LV pulses simultaneously on all channels.

3.6.6.2 MPS LV Status Simulation

AVI-3573/CREATED/T

MPS LV Status Simulation function shall be provided by relay simulation (16x) of each LV STATUS micro-switch.

AVI-3574/CREATED/T

LV Status Simulation shall conform to the following specifications: [AD06] Table 3.5-28 (Relay Status Acquisition Source Specification).

AVI-3575/CREATED/T

In open-loop test modes LV STATUS (OPEN/CLOSE) relay shall be set to the STATE value of the corresponding LV command pulse acquisition (see AVI-3560).

AVI-3576/CREATED/T

In open-loop test modes, it shall be possible to overwrite the LV STATUS from the local MMI or from the CCS (Test Procedure/Command Line).

Note: This allows error injection into the MPE - Latch Valve Status not reflecting the commanded operation.

AVI-3577/CREATED/T

In closed-loop test mode, LV STATUS shall be defined by the RTS.

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3.6.6.3 MPS FCV Command Pulse Acquisition

AVI-3579/GSE-SYS-740/T

The MPS FCV Command Pulse Acquisition interface shall be provided by fixed loads (16x) simulating each of the FCV coils.

AVI-3580/GSE-SYS-740/T

The FCV Command Acquisition interface shall conform to the following specifications: [AD06] Table 3.5-36 (Flow Control Valve Interface Specification - Receiver Circuit Specification).

AVI-3581/GSE-SYS-740/T

*FCV Command Pulse Acquisition shall provide measurements of the **integrated** ON time for each FCV, the individual command pulse widths and an event count per FCV, as detailed below:*

EVENT COUNT limit	65536
ON time resolution	5 %
Pulse WIDTH resolution	100.0 µs - for pulse widths 5ms to continuous

Table 3.6-5: CPS - FCV Command Pulse Measurement Specification

AVI-3593/CREATED/T

*Once an FCV Command has triggered, ON time measurements shall be integrated every 15.625 ms (equivalent to the RTS Simulation Cycle rate of 1/64 of the Major Frame rate) and calculated as percentage (ON) over the integration period. **TBC***

Note: Although the CPS Model in the RTS executes at 64Hz in real-time, thrust vectors output to the Dynamics Model need to consider thruster pulses to an accuracy of <1ms.

AVI-3595/CREATED/T

Measurement of LV Command pulses shall be triggered asynchronously by detection of an incoming pulse with the following specifications:

- *Pulse Width > 1ms*
- *Pulse Amplitude > 10.0V*

AVI-3596/CREATED/T

It shall be possible to reset the event counters, individually or all at once, by command from the local MMI or from the CCS (Test Procedure/Command Line)..

AVI-3597/GSE-SYS-740/T

FCV ON times shall be made available to the RTS for closed-loop testing.

AVI-3598/GSE-SYS-756/T

It shall be possible to acquire the FCV pulses simultaneously on all channels.

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3.6.6.4 MPS Gas Flow Sensor Simulation

AVI-629/GSE-SYS-739/T

The MPS Gas Flow Sensor Simulation shall simulate the presence of (16x) Gas Flow Monitor Sensors.

AVI-644/CREATED/T

The MPS Gas Flow Sensor driver shall conform to the following specifications: [AD06] Table 3.5-10 (Analog Driver Specification 2).

AVI-1612/CREATED/T

In all test modes, Gas Flow Simulation values shall be set asynchronously to simulate the Gas Flow determined by the corresponding FCV pulse acquisition (see AVI-3581), using the following formula: ***TBD***

AVI-1613/GSE-SYS-739/T

To facilitate error injection towards the MPE, it shall be possible to overwrite the nominal coupled Gas Flow Simulation from the local MMI or from the CCS (Test Procedure/Command Line).

AVI-4240/GSE-SYS-755/T

Simulation of all Gaz Flow Sensors shall be possible in parallel.

3.6.6.5 MPS Pressure Transducer Simulation

AVI-584/GSE-SYS-738/T

The MPS Pressure Transducer (PT) Simulation shall simulate the presence of 16 regulated pressure transducers.

AVI-1616/CREATED/T

MPS Pressure Transducer Simulation shall conform to the requirements of: [AD06] Table 3.5-12 (Analog Driver Specification 3)

AVI-1617/CREATED/T

In open-loop test mode Simulated Pressures shall be commanded asynchronously by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1618/CREATED/T

In closed-loop test mode Simulated Pressures shall be commanded by the RTS.

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3.6.7 Fine Sun Sensor Interfaces

Gaia comprises 3 Fine Sun Sensors (FSS) cross-strapped to each EIU.

Each FSS provides (see Figure 3.6-3):

- A Detector Voltage signal to the EIU, selected from one-of-eight multiplexed voltages;
  - Q1 - Q4 being representative of the sun incidence on each of the FSS detector quadrants
  - T1 - T4 being test voltages to allow closed-loop system testing with FSS HWIL.
- 3 address lines inputs (A0 - A2) for multiplex selection.
- A 'Sun Presence' voltage signal to the EIU (being the sum of Q1 - Q4).
- Inputs for 4 test voltages (T1 - T4) to verify operation of the FSS conditioning electronics and allow FSS HWIL testing.
- A built-in thermistor to provide temperature data to the EIU.

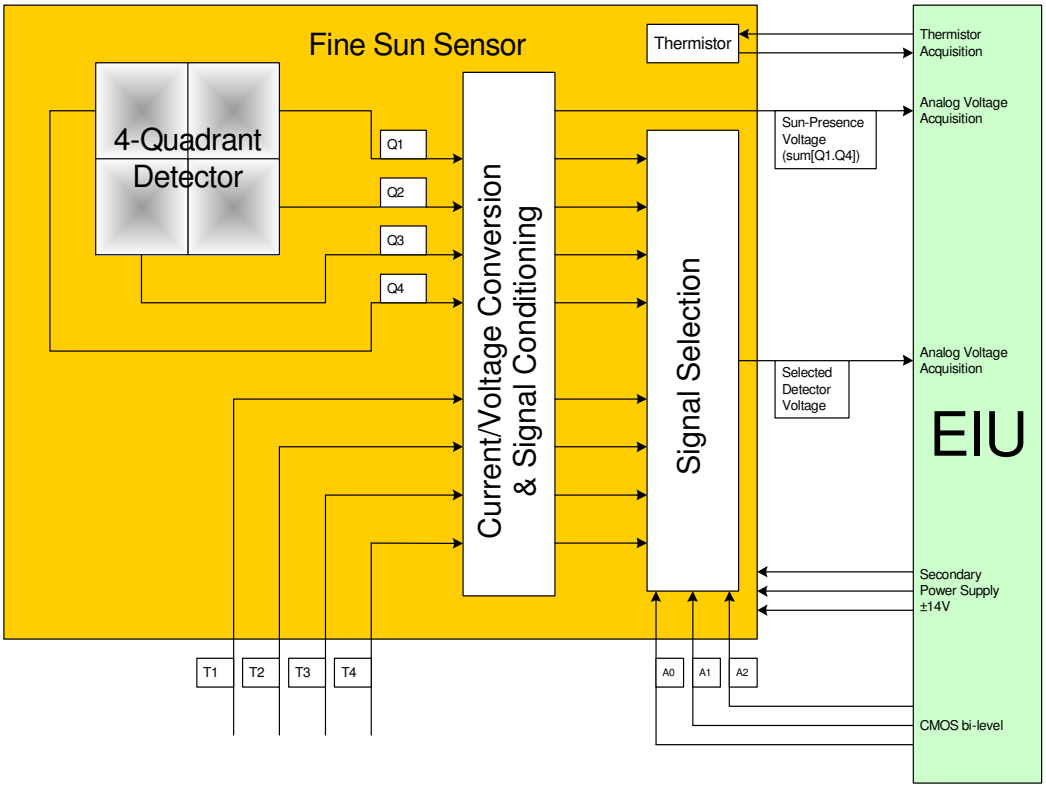

Figure 3.6-3: FSS - Block Diagram

AVI-4142/CREATED/T

The Avionics SCOE shall provide facilities for FSS Simulation (towards the EIU) and for stimulating the FSS with test voltages when the real FFS are HWIL.

AVI-4143/CREATED/T

It shall be possible to select either FSS Simulation mode or FSS HWIL Test for any of the 3 FSS independently.

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3.6.7.1 FSS Simulation

AVI-750/GSE-SYS-404/T

For simulation of each FSS, the Avionics SCOE shall provide the following interfaces:

1 x Detector Voltage Simulation output (representing Q1 - Q4 or T1 - T4, as selected)
1 x 'Sun Presence' Voltage Simulation output (being the sum of Q1 - Q4)
Acquisition of 3 x EIU address line inputs (A0 - A2, for selection of the Detector Voltage Simulation output)

AVI-751/CREATED/T

Detector Voltage Simulation and 'Sun Presence' Voltage Simulation outputs shall conform to the following specification: [AD06] Table 3.5-10 (Analog Driver Specification 2).

AVI-753/EIU-1173/T

EIU Address Line Acquisition shall conform to the following specification: CMOS Compatible, 0V - 12V nominal.

AVI-756/CREATED/T

Selection of the output voltage for Detector Voltage Simulation shall be determined by the EIU Address Lines in accordance with the following truth table:

A0	A1	A2	Detector Voltage Simulation
0	0	0	Q1
0	0	1	Q2
0	1	0	Q3
0	1	1	Q4
1	0	0	T1
1	0	1	T2
1	1	0	T3
1	1	1	T4

Table 3.6-6: FSS - Address Line Truth Table Specification

Figure 3.6-4 shows typical timing of FSS Acquisition by the EIU:

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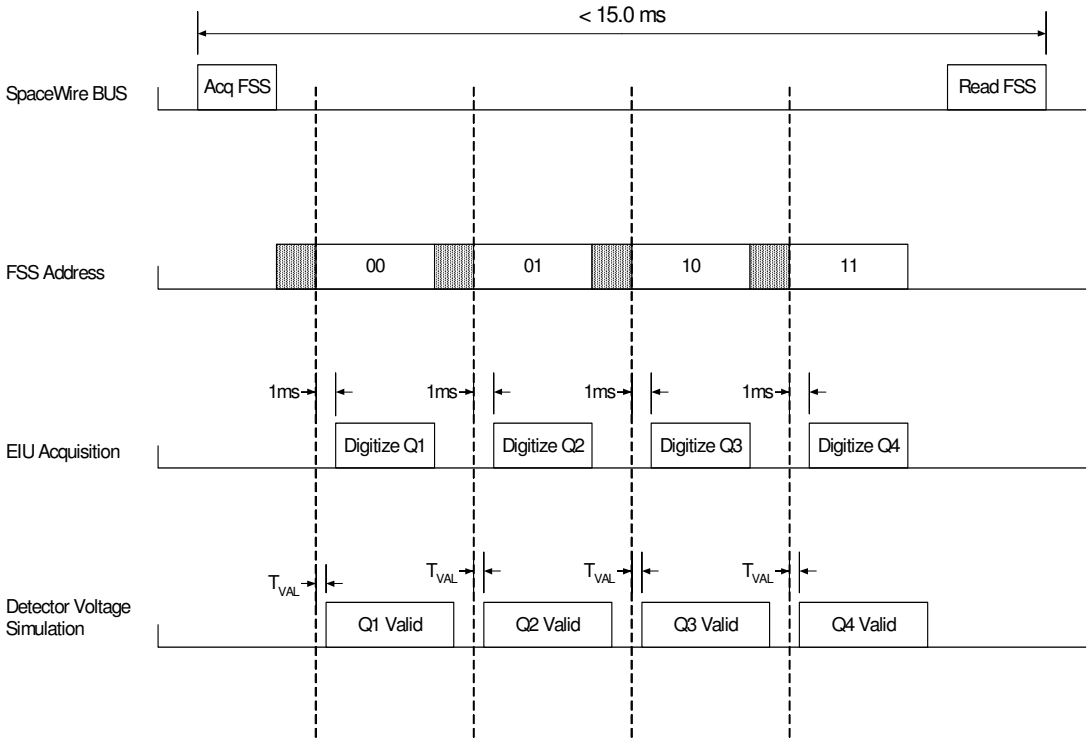

Figure 3.6-4: FSS Acquisition Timing

AVI-2823/CREATED/T

The value applied at the Detector Voltage Simulation output shall be one of Q1 - Q4 or T1 - T4, in accordance with the address acquired from the EIU (A0 - A2) - see Table 3.6-6.

AVI-2825/EIU-3020/T

The acquisition of FSS Address Lines (A0 - A2) from the EIU shall be asynchronous, triggered by a change in the FSS Address.

AVI-1601/EIU-3020/T

The value of Selected Detector Voltage (Q1 - Q4, or T1 - T4) sent to the EIU shall be valid within T_{VAL} ms of the appropriate address being sent by the EIU, where T_{VAL} = < 1ms.

AVI-1598/CREATED/T

In open-loop test mode, the values of (Q1 - Q4, T1 - T4) shall be set by the local MMI or CCS (Test Procedure/Command Line).

AVI-2826/CREATED/T

In open-loop test mode, the value of the 'Sun Presence' signal shall be calculated by the Avionics SCOE as the sum of the (Q1 - Q4) voltages.

AVI-1600/CREATED/T

In closed-loop test mode, the values of (Q1 - Q4, T1 - T4) and the 'Sun Presence' signal shall be determined by the RTS (FSS Models).

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3.6.7.2 FSS HWIL Test

When an FSS is HWIL, Test Voltages (T1 - T4) can be applied to the FSS. Selection of the Test Voltages is made by setting HIGH the A2 address line (from the EIU) to the FSS (see AVI-756).

To prevent the need to adapt the EIU, or the CDMU Central Software, it is required to interrupt Address Line A0 between the EIU and the FSS and set the Line HIGH towards the FSS.

During FSS HWIL testing, an Astrium Ltd provided test adapter is used at the FSS test (skin) connector to achieve this.

As the FSS does not provide a Sun Presence Signal relative to the Test Voltage inputs, it is also necessary to simulate this signal when FSS is HWIL.

AVI-4145/CREATED/T

For testing when FSS is HWIL, the Avionics SCOE shall provide the following interfaces:

4 x Test Voltage Stimulus outputs (T1 - T4) to the FSS
1 x 'Sun Presence' Voltage Simulation output (being the sum of T1 - T4) to the EIU (this being the same signal used for FSS Simulation - Section 3.6.7.1)

AVI-4153/CREATED/T

Test Voltage Stimulus outputs (T1 - T4) and 'Sun Presence' Voltage Simulation outputs shall conform to the following specification: [AD06] Table 3.5-10 (Analog Driver Specification 2).

AVI-4208/CREATED/T

In open-loop test mode, the values of T1 - T4 shall be set by the local MMI or CCS (Test Procedure/Command Line).

AVI-4209/CREATED/T

In open-loop test mode, the value of the 'Sun Presence' signal shall be calculated by the Avionics SCOE as the sum of the T1 - T4 voltages.

AVI-4210/CREATED/T

In closed-loop test mode, the values of T1 - T4 and the 'Sun Presence' signal shall be determined by the RTS (FSS Models).

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3.6.8 Gyro HWIL Stimulation

The following requirements will be considered as **TBC** pending Gyro supplier selection. The requirements given are indicative of the interfaces and necessary functionality to be provided.

Gaia comprises 3 Gyro Packages connected to the SVM 1553 BUS.

Each Gyro package offers redundant rate measurement about a single axis.

For each Gyro package, test inputs are available to allow rate bias to be added to the prime and redundant output channels when Gyros are HWIL.

AVI-936/GSE-SYS-745/T

For each Gyro package, the Avionics SCOE shall provide 2x (RS422) test interfaces as defined in: [AD06] Table 3.5-5 (SBL Driver Specification) and Table 3.5-6 (SBL Receiver Specification).

AVI-1052/CREATED/T

In open loop test mode simulated angular rates shall be set at the local MMI or CCS (Test Procedure/Command Line).

AVI-1053/CREATED/T

In closed loop test mode the RTS shall send the simulated angular rates for all Gyro channels configured for HWIL operation.

AVI-1891/GSE-SYS-751/T

The Avionics SCOE shall be capable of supporting simultaneous update in closed-loop mode of all 6 Gyro channels.

AVI-2830/CREATED/T

*The data message structure to be output on the RS422 to the Gyro units shall be as defined in the Gyro ICD **TBD**.*

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3.6.9 Standard High Power Pulse Command Generation

The Gaia EIU provides 48+48 Standard High Power Pulse Commands (SHP) for de-centralised power switching or reconfiguration of Spacecraft units.

AVI-3599/CREATED/T

To allow testing of the Spacecraft when the EIU is missing the Avionics SCOE shall provide SHP generation in place of the EIU.

AVI-1075/EIU-754,EIU-755,GSE-SYS-398/T

The Avionics SCOE shall provide simulation of 96 SHP outputs in accordance with the following interface specification: [AD06] Table 3.5-22 (SHP Command Source Specification).

AVI-1091/GSE-SYS-398/T

In all test modes, the Avionics SCOE shall generate SHP commands asynchronously in accordance with commands received on the CDMU/EIU SpaceWire BUS.

AVI-3600/GSE-SYS-398/T

In all test modes, generation of an SHP command shall occur within 10ms of reception of its corresponding command received on the CDMU/EIU SpaceWire BUS.

3.6.10 Standard High Power Pulse Command Acquisition

The Gaia Spacecraft provides Standard High Power (SHP) Pulse Commands for de-centralised power switching and reconfiguration of Spacecraft units. SHP generation is distributed among the Spacecraft units as follows:

- 48+48 Type 1 SHP - CDMU
- 48+48 Type 1 SHP - EIU

AVI-1144/EIU-754,EIU-755, CDMU-754,CDMU-755, GSE-SYS-744/T

The Avionics SCOE shall provide interfaces to acquire 192 SHP commands in accordance with the following interface specification: [AD06] Table 3.5-23 (SHP Command Receiver Specification)

AVI-1626/CREATED/T

SHP Acquisition shall provide status (ON/OFF) and measurement of the individual command pulse widths as detailed below:

Pulse Width measurement resolution	100.0 us - for nominal pulse width 32-64ms

Table 3.6-7: SHP Command Pulse Measurement Specification

AVI-1890/CREATED/T

Measurement of SHP Command pulses shall be triggered asynchronously by detection of an incoming pulse with the following specifications:

- *Pulse Width > 1ms*
- *Pulse Amplitude > 10.0V*

AVI-1629/CREATED/T

SHP status (ON/OFF) shall be made available to the RTS for closed-loop testing.

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3.6.11 Alarm Simulation Interface

Each Gaia CDMU provides monitoring capability of 8 Alarm inputs, as single ended switch-closure (SAC) inputs.

AVI-1254/CDMU-793,CDMU-794/T

Alarm Simulation shall conform to the requirements of: [AD06] Table 3.5-28 (Relay Status Acquisition Source Specification)

Note: The SAC driver interface specification is identical to RSA.

AVI-1639/CREATED/T

In open-loop test mode Alarm Inputs shall be commanded by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1640/CREATED/T

In closed loop test mode the RTS shall command the Alarm Inputs.

3.6.12 Bi-level Telemetry Status Simulation Interface

The Gaia EIU provides monitoring capability of 32 Bi-level Telemetry Status inputs.

AVI-1648/EIU-797,EIU-798/T

The Avionics SCOE shall provide 32 Bi-Level TM Status Simulation inputs to the GAIA EIU in accordance with the following interface specification: [AD06] Table 3.5-33 (Bi-level Digital Source Specification)

AVI-1649/CREATED/T

In open-loop test mode Status Inputs shall be commanded by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1650/CREATED/T

In closed loop test mode the RTS shall command the Bi-Level Telemetry Status.

3.6.13 Separation Strap Simulation

The EIU provides a facility for measuring the status of the GAIA Launch Separation Straps.

AVI-2890/EIU-780/T

The Avionics SCOE shall provide simulation of 5 relay closures for input to the EIU.

AVI-2891/EIU-782/T

Relay Closure simulation shall conform to the requirements of: [AD06] Table 3.5-28 (Relay Status Acquisition Source Specification)

AVI-2892/CREATED/T

In open-loop test mode Separation Strap state shall be commanded by local MMI or by the CCS (Test Procedure or Command Line).

AVI-2893/CREATED/T

In closed loop test mode, the RTS shall command the Separation Strap states required.

3.6.14 Relay Status Simulation

The CDMU and EIU provide a facility for measuring the status of relay closure inputs.

AVI-1673/EIU-780/T

The Avionics SCOE shall provide simulation of 2 (CDMU) and 128 (EIU) relay closures.

Note: The quantity defined here for the EIU includes those allocated for CPS LV Status Simulation - Section 3.6.5.2 - and Separation Strap monitoring, Section 3.6.13.

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AVI-1674/EIU-782/T

Relay Closure simulation shall conform to the requirements of: [AD06] Table 3.5-28 (Relay Status Acquisition Source Specification)

AVI-1679/CREATED/T

In open-loop test mode Relay state shall be commanded by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1680/CREATED/T

In closed loop test mode, the RTS shall command the Relay state required.

3.6.15 Analog Voltage Simulation

The EIU provides a facility for measuring input voltages.

AVI-1683/EIU-804,EIU-809/T

The Avionics SCOE shall provide simulation of 16 type AN1, 48 type AN2 and 20 type AN3 Voltage outputs towards the EIU.

*Note[1]: The AN2 allocation **includes** those already specified for FSS Simulation/Stimulation (Sections AVI-4141 and AVI-4144).*

Note[2]: The AN3 allocation are those already specified for CPS/MPS Pressure Transducer Simulation (Sections AVI-401 and AVI-583).

AVI-1684/CREATED/T

AN1 Voltage simulation shall conform to the requirements of: [AD06] Table 3.5-8 (Analog Driver Specification 1)

AVI-1688/EIU-805,EIU-801/T

AN2 Voltage simulation shall conform to the requirements of: [AD06] Table 3.5-10 (Analog Driver Specification 2)

AVI-4230/CREATED/T

AN3 Voltage simulation shall conform to the requirements of: [AD06] Table 3.5-12 (Analog Driver Specification 3)

AVI-4231/CREATED/T

All Voltage simulation outputs shall have a setting resolution of <10mV.

AVI-4232/CREATED/T

All Voltage simulation outputs shall have a setting accuracy of <10mV.

AVI-1685/CREATED/T

In open-loop test mode Voltage simulation levels shall be commanded by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1686/CREATED/T

In closed loop test mode, the RTS shall command the Voltage simulation levels.

As a means to reduce channel overhead on the Analog Simulation instruments, the subcontractor may consider supplying a single Analog Interface type (i.e., AN3) providing the requirements of AVI-4231 and AVI-4232 are met.

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3.6.16 SREM Simulation

The Gaia Spacecraft includes a Spacecraft Radiation Environmental Monitor (SREM) unit, which interfaces to the EIU using a point-to-point RS422 link.

AVI-1958/CREATED/

The Avionics SCOE shall provide simulation of the SREM as an interface to the EIU.

AVI-1959/EIU-2294,EIU-2295/T

The SREM interface shall acquire the following differential RS422 signals from the EIU in accordance with the requirements of: [AD06] Table 3.5-6 (SBDL Receiver Specification). ***TBC***

- *TC_sample*
- *TC_data*
- *TM_sample*
- *Clock*

AVI-1963/EIU-2294,EIU-2295/T

The SREM interface shall provide a differential RS422 ***TM_data*** *signal to the EIU in accordance with the requirements of: [AD06] Table 3.5-5 (SBL Driver Specification).* ***TBC***

AVI-1960/EIU-2296/T

The SREM simulation shall conform to the Telecommand and Telemetry specifications defined in the SREM ICD (Sections 6.2 and 6.3 respectively of [AD07]).

AVI-1961/CREATED/T

In open-loop test mode Telemetry data provided on the ***TM_data*** *interface shall be defined initially by input file.*

AVI-1970/CREATED/T

The SREM data input file shall be a human-readable file (such as XML) in a format to be defined by the Avionics SCOE subcontractor.

AVI-1969/CREATED/T

In open-loop test mode it shall be possible to modify individual parameters of SREM Telemetry data by local MMI or by the CCS (Test Procedure or Command Line).

AVI-1962/CREATED/T

In closed loop test mode, the RTS shall acquire the SREM input data and define the response on the ***TM_data*** *line.*

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3.6.17 EGSE Synchronisation Pulse

AVI-3332/CREATED/T

For synchronisation to CCS, the Avionics SCOE shall provide a synchronisation pulse to the PLM End-to-End Simulator.

AVI-3333/CREATED/T

Generation of the synchronisation pulse shall be triggered ON from the local MMI or by command from the CCS (Test Procedure).

AVI-3336/CREATED/T

Generation of the synchronisation pulse shall be logged using the Event Log process (see Section 3.9.3).

AVI-3337/CREATED/T

The CDU-EGSE synchronisation pulse shall conform to the following specification.

Interface Type	TTL
OFF State	TTL Low Level
ON State	TTL High Level
Pulse Width (ON duration)	10ms ±1%

Table 3.6-8: EGSE Synchronisation Pulse Specification

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3.7 CCS Interface Requirements

AVI-1575/CREATED/T

The Avionics SCOE interface to the CCS shall be via the Network Interface (LAN) Card using TCP-IP protocols.

AVI-3365/GSE-SYS-770/T

Three distinct interface types shall be provided for Avionics SCOE to CCS data transfers, as defined in the following sections:

- *Standard SCOE HK TM / Command & Control interface*
- *SCET/H_{REF} data pair transfer*
- *Transport Sample Protocol (TSP) interface for data logging to CCS Processing and Central Archive.*

3.7.1 HK TM / Command & Control Interface

AVI-1576/CREATED/T

*Standard HK TM messages sent **to** the CCS shall utilize the EGSE Internal Housekeeping TM Source Packet structure defined in Section 3.4.3 of the EGSE ICD [AD01].*

AVI-2805/CREATED/T

*Command & Control messages sent **by** the CCS shall utilize the EGSE Command and Control Source Packet structure defined in Section 3.4.4 of the EGSE ICD [AD01].*

AVI-2804/CREATED/T

HK TM and Command & Control messages from/to the CCS shall contain the Application ID as given in Appendix 2 of the EGSE ICD [AD01] for the Avionics SCOE.

AVI-2803/CREATED/T

Where applicable, message protocols shall conform to (but not be restricted to) the Keyword List identified in Section 3.4.4.2 of the EGSE ICD [AD01].

AVI-1577/CREATED/T

All data received from the CCS shall be acknowledged by ACK/NAK reply in accordance with Section 3.4.4 of the EGSE ICD [AD01].

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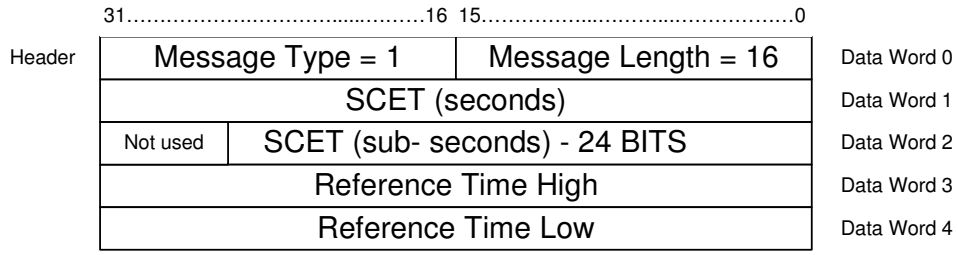
3.7.2 SCET/HREF Interface

AVI-3369/CREATED/T

SCET/H_{REF} data pairs (as defined in Section 3.5.4) shall be transferred to the CCS for SCET/UTC correlation every PPS.

AVI-3370/CREATED/T

The data pairs shall be transferred to the CCS in network byte order using the message format defined in Figure 3.7-1.



where:

- Data Word 0 is the message header comprising the Message Type (MS 16 BITS) set to a value of 1, and the Message Length (LS 16 BITS), set to 16.
- Data Word 1 contains the MS 32 BITS of the SCET (corresponding to the seconds component)
- Data Word 2 (lower 3 bytes) contains the LS 24 BITS of the SCET (corresponding to the sub-second component)
- Data Word 3 contains the MS 32 BITS of H_{REF}
- Data Word 4 contains the LS 32 BITS of H_{REF}

Note: H_{REF} comprises a 64 BIT Integer equivalent to the number of microseconds since the beginning of the current year.

Figure 3.7-1: SCET/H_{REF} Data Transfer Format

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3.7.3 TSP Interface

AVI-3372/CREATED/T

Transfer of all acquired synchronous and asynchronous data to the CCS (for Processing and Central Archive) shall utilise the Transport Sample Protocol over the EGSE LAN.

AVI-3373/CREATED/T

The Avionics SCOE shall be the TSP Provider, with the CCS the TSP Consumer.

AVI-3374/CREATED/T

Using TSP, the Avionics SCOE shall implement a separate link for each synchronous data sample rate, and a single link for the transfer of asynchronous data.

AVI-4222/CREATED/T

For each separate TSP synchronous data link, the first parameter at each sample rate shall be the reference time (T_{REF}).

AVI-4223/CREATED/T

For the TSP asynchronous data link, each logged parameter shall include the reference time (T_{REF}) at which the parameter was acquired.

The TSP protocol is described in Section 3.3 of the EGSE ICD [AD01].

AVI-3376/CREATED/T

As a contingency measure (in the event the TSP link to the CCS is lost) the Avionics SCOE shall implement a Consumer side TSP link to itself and stream archive data to "RES" format files on local disc. The "RES" file format is defined in Section 7 of the EGSE ICD [AD01].

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3.8 EGSE Real Time Network Interface Requirements

AVI-1407/CREATED/T

For closed-loop testing of Gaia AOCS, in the AVM Bench or PFM/AIT configuration, data values output to the Spacecraft, and data values input from the Spacecraft, shall be transferred from/to the Real Time Simulator (RTS).

AVI-1416/CREATED/R

For transfer of data with the RTS, the Avionics SCOE shall form part of a Real-Time Network (also known as a Reflective Memory or Distributed Shared Memory Network) with the RTS and other EGSE (Star Tracker SCOE and Dynamic FPA Simulator).

AVI-1417/CREATED/I,R

The Real Time Network (RTN) architecture has been selected by the RTS supplier. The Avionics SCOE subcontractor shall implement the RTN connection using an interface card chosen from the 'GE Fanuc Embedded Systems' Reflective Memory range, which offers the following devices:

Note: Further details may be found at: www.gefanucembedded.com/products/family/135/

Part Number	Form Factor	Memory Type	Memory Capacity
PCI-5565	PCI	SDRAM	64 MB
PMC-5565	PCM	SDRAM	64 MB
VME-5565	VME	SDRAM	64 MB
CLB-5565	PCI	SDRAM	64 MB

3.8.1 Real-Time Network Synchronisation and Data Transfer

AVI-2990/CREATED/T

The Avionics SCOE shall provide the synchronisation signals to all EGSE on the Real Time Network RTN):

- *Real Time Simulator*
- *Dynamic FPA Simulator*
- *Star Tracker SCOE (2x)*

AVI-2991/CREATED/T

Synchronisation shall be in the form of global interrupts on the RTN co-incident with the CSW Major and Minor Frame control cycles (see Section 3.5.2).

Transfer of low-level (discrete) I/O between the RTS and the Avionics SCOE will be initiated by the RTS.

Data transfer for discrete I/O will be implemented at a Simulation Cycle maximum rate of 1/64 of the CSW Major Frame control cycle (nominally 64 Hz).

The RTS will perform an interrupt-driven DMA read cycle at a fixed point at the beginning of the Simulation Cycle to transfer discrete data acquired by the Avionics SCOE (from the Spacecraft Interfaces).

The RTS will perform an interrupt-driven DMA write cycle at a fixed point near the end of the Simulation Cycle to transfer discrete data to the Avionics SCOE (for generation towards the Spacecraft Interfaces).

The intent of AVI-3003 and AVI-3002 (DMA usage) is to reduce overall data-latency for low-level data transfers and to de-couple such transfers from the RTS Model execution schedule to reduce jitter at the Spacecraft Interfaces (when compared to on-demand transfer).

AVI-4227/CREATED/T

The latency between the RTS interrupt for the DMA write cycle and the update of data at the Spacecraft Interfaces shall be <1ms in all cases.

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3.8.2 Real-Time Network Definition & Responsibility

This Section defines the general principles controlling the definition of the RTS to Avionics SCOE interfaces. The detail and performance are to be agreed with the RTS supplier as part of the co-engineering activity defined in Section 4.

Operation of the Real-Time Network requires definition of the following processes:

Mapping of RTS Model discrete I/O variables to the RTN Reflective Memory (for Avionics SCOE, Dynamic FPA Simulator and Star Tracker SCOE)
Calibration of discrete data output from RTS Models to real values required at the Spacecraft Interfaces
Calibration of discrete data input to RTS Model from real values acquired at the Spacecraft Interfaces

As the RTS provides data to all other EGSE on the RTN, Reflective Memory mapping will be the responsibility of the RTS supplier.

The RTS supplier will provide a Memory Map file (in a format to be determined by them) which will determine Reflective Memory address locations, data size and data type for all discrete data passed across the RTN.

The Memory Map file will refer to data by Symbolic Name and reference RFM locations by offset from the RFM base address.

The RFM Memory Map file will be one input to an overall Real Time Network ICD to be developed between The Avionics SCOE and RTS suppliers (see Section 4).

AVI-1454/CREATED/T

The Avionics SCOE shall utilize the memory Map file to determine its transfer of data between RFM and the Spacecraft Interfaces.

AVI-1455/CREATED/R

Any data conversion and/or calibration requirements between RFM data types and those required for Spacecraft I/O shall be the joint responsibility of the Avionics SCOE and RTS supplier, and be determined as part of a co-engineering task between the Avionics SCOE and RTS suppliers (see Section 4).

AVI-3025/CREATED/R

Any interface requirements between the Avionics SCOE and the RTS (such as asynchronous operation for BUS transfers, high-level configuration requirements, calibration, for example) shall be determined as part of a co-engineering task between the Avionics SCOE and RTS suppliers (see Section 4).

The interface between the RTS and the Avionics SCOE is critical to the operation of the Avionics SCOE as one component of a real-time closed-loop system. Section 4 defines the processes to be undertaken by the Avionics SCOE subcontractor to ensure correct operation of this interface.

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3.9 Application Software Requirements

AVI-1465/CREATED/T

The Avionics SCOE Application Software shall provide the following functions:

Initialization of the SCOE
Control & Monitoring Sessions
Data Logging
Command & Control Link to the CCS
Avionics SCOE MMI

3.9.1 Initialization of the SCOE

AVI-1466/CREATED/T

The Avionics SCOE initialization process shall be scheduled automatically at start up, and shall include:

Configuring the instrument interfaces to the Spacecraft
Map data I/O symbols to hardware channels
Setting up default values to the Spacecraft hardware
Defining the initial data logging scheme
Setting up the interface to the RTS
Establishing a link to the CCS (if connected)

AVI-1505/CREATED/T

The initialization process shall configure all instrumentation hardware for nominal operation.

AVI-1509/CREATED/T

All data I/O with the Spacecraft interfaces are identified by software Symbolic Name (see Appendix A). Mapping of the SCOE hardware channels to Symbolic Name shall be defined in an initialization file.

AVI-1511/CREATED/T

The initialization process shall map the SCOE hardware channels by Symbolic Name defined in the initialization file.

AVI-1512/CREATED/T

All instrumentation providing stimulus to the Spacecraft interfaces shall be configured for default output values.

AVI-1513/CREATED/T

Default stimulus values shall be defined in an initialization file.

AVI-1896/CREATED/T

Default 1553 and SpaceWire BUS configuration shall be defined in an initialization file (i.e., which RT or SpaceWire terminals need to be simulated to replace missing Spacecraft units).

AVI-1514/CREATED/T

For closed loop operation (the RTS defining the data I/O), the RTS shall define the initialization parameters.

AVI-1904/CREATED/T

The default Data Log Schedule shall be defined initially by initialisation file.

AVI-1905/CREATED/T

The Datalog initialisation file shall determine which parameters are to be routinely logged (locally, to the CCS or both) and/or displayed, and the nominal data logging rates.

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AVI-1906/CREATED/T

The Data Log Schedule shall define data logging parameters by their Symbolic Name.

AVI-1907/CREATED/T

The Application Software shall provide a simple MMI tool for viewing and updating the Data Log Schedule and Data Log Init File.

AVI-1515/CREATED/T

The Application Software shall flag warnings to the System log for any unmapped Symbols or any Symbols mapped to undefined memory areas.

AVI-1516/CREATED/T

It shall be possible to reinitialize the SCOE at any time by command from the CCS or by operator request from the SCOE MMI.

AVI-1517/CREATED/T

The initialization process shall establish the data link to the CCS, in accordance with the protocols defined in the EGSE ICD [AD01].

3.9.2 Control and Monitoring Sessions

AVI-1518/CREATED/T

Once initialized, the Avionics SCOE shall provide 3 modes of operation:

Local open-loop session
Remote open-loop session
Remote closed-loop session

AVI-1519/CREATED/T

The local open-loop session shall be under the control of the SCOE MMI.

AVI-1520/CREATED/T

The remote open-loop session shall be under the control of the CCS, by Command Line or Test Procedure.

AVI-1521/CREATED/T

The remote closed-loop session shall be under the control of the CCS, with the RTS directly controlling predefined data I/O to the Spacecraft interfaces.

AVI-1549/CREATED/T

The data acquisition cycle shall acquire and generate data in accordance with the requirements of Section 3.9.1.

AVI-2853/CREATED/T

Archive of Spacecraft I/O parameters to local file or the CCS shall be implemented in accordance with the Data Log Schedule (see Section 3.9.3).

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3.9.3 Data Logging and Archive

Data logging is the process by which the Avionics SCOE archives data and information about the Simulation process.

AVI-1913/CREATED/T

Data shall be logged in accordance with the current data logging schedule.

AVI-1914/CREATED/T

Data shall be logged to the CCS in accordance with the current data logging schedule (defined during initialization and adapted via the Avionics SCOE MMI or by definition from the CCS [Test Procedure/Command Line]).

AVI-1915/CREATED/T

The following separate and distinct local log files shall be created and maintained throughout a session:

Log files for the 1553 BUS Spies
Log files for the SpaceWire BUS Spies
Log files for the PacketWire BUS Spies
Event Log File, to include:
• Command Logs from the C&C Interface
• Command Logs from the Avionics SCOE MMI
• Error and Warning Messages

AVI-1941/CREATED/T

Normal Parameter Logging shall be to the CCS Central Archive using TSP (as defined in Section 3.7.3).

AVI-1947/CREATED/T

The 1553 and SpaceWire Log Files shall be used to archive the data transfers on each of the BUS identified.

AVI-1955/CREATED/T

At shall be possible to turn ON/OFF logging of each 1553 or SpaceWire BUS.

AVI-1954/CREATED/T

When initiated by Test Sequence (from the CCS), log files shall be associated with the calling Sequence.

AVI-1948/CREATED/T

All Messages to the Event Log File shall be tagged with one of the classifications: MESSAGE, WARNING or ERROR.

AVI-1949/CREATED/T

All data and messages shall be time-stamped with the reference time (T_{REF}) - see Section 3.5.1.

AVI-4220/CREATED/T

All log files created shall include the calling sequence (if defined) and the date/time in the file name.

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3.9.4 Command and Control Interface

AVI-1972/CREATED/R

The Command and Control Interface (C&C) shall provide the interface between the Avionics SCOE (Application Software) and the CCS.

AVI-1973/CREATED/

The C&C shall accept, decode and execute commands from the following sources:

Avionics SCOE MMI
CCS (Command Line)
CCS (Test Sequence)

AVI-1981/CREATED/T

The C&C data exchange with the CCS shall utilize the message protocols defined in [AD01] Section 3.7.

AVI-1985/CREATED/T

The C&C shall generate Messages to the Event Log File detailing all commands received, decoded and executed.

AVI-1986/CREATED/T

All commands received which cannot be decoded (i.e. containing syntax errors, unrecognized or out of sequence commands) shall generate a Warning Message to the Event Log File (see Section 3.9.3).

AVI-1987/CREATED/T

Loss of the interface to the CCS shall not corrupt the current monitoring Session.

AVI-1988/CREATED/T

If lost, the Avionics SCOE shall re-establish the C&C interface automatically using the standard client/server protocols defined in [AD01] Section 3.2.

3.9.4.1 C&C Command Interpreter

AVI-1990/CREATED/T

The C&C shall provide a command structure and interpreter to provide the following features:

Avionics SCOE Session control:
• Start a Session with current parameter settings (if issued from a CCS Test Sequence, the Sequence name shall be defined by the user)
• Stop the current Session (close out log files)
• Reset the Avionics SCOE (reload default parameter values)
Spacecraft Interface Parameter control:
• Set any Parameter
• Read any Parameter
• Define data logging for any Parameter

AVI-2010/CREATED/T

It shall be possible to set any Spacecraft Interface Parameter for adaptation purposes and fault injection.

AVI-2020/CREATED/T

It shall be possible to set any Spacecraft Interface Parameter while a Session is running.

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AVI-2021/CREATED/T

In the remote closed-loop session, the C&C shall not allow adaptation of any Spacecraft Interface Parameter under direct control of the RTS (as defined during initialisation of the RTS Interface - see Section 3.9.1).

AVI-2076/CREATED/T

Parameter adaptation shall be user-definable as follows:

• One-shot (for a single acquisition).
• Timed (for a fixed number of acquisitions).
• Lock (freeze at current value).
• Unlock
• Ramp (with user-defined start/stop and step values).
• Simulate (by explicit values from a user-defined file).

AVI-2035/CREATED/T

It shall be possible to read the current value of any Spacecraft Interface Parameter.

AVI-2036/CREATED/T

It shall be possible to adapt the Data Logging schedule for all Parameters defined.

AVI-2037/CREATED/T

The logging process command shall be user-defined as follows:

• One-shot (report value on next acquisition)
• Periodical (logged repetitively at the nominal acquisition rate).
• Location (to local log file and/or to local MMI display and/or to CCS).
• Disable (data logging for the parameter defined)
• Enable (data logging for the parameter defined)

AVI-2051/CREATED/A,R

Where appropriate, commands shall reference Spacecraft Interface Parameters by their Symbolic Name.

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3.9.5 Avionics SCOE MMI

AVI-2078/CREATED/T

The Avionics SCOE Application Software shall provide an MMI for Operator control of the SCOE.

AVI-2079/CREATED/T

All control processes identified in Section 3.9.4 shall be available under Operator control from the MMI.

AVI-2080/CREATED/T

The MMI shall provide displays of user-specified Spacecraft Interface Parameters (defined by Symbolic Name).

AVI-2081/CREATED/T

It shall be possible to view both the raw and calibrated data associated with the Spacecraft Interface Parameters.

AVI-2082/CREATED/T

The MMI shall provide a separate display corresponding to the Event Log defined in Section 3.9.3.

Intuitive Graphical User Interface (GUI) of the various Spacecraft Interface subsystems will be considered a useful tool for adaptation and monitoring purposes.

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3.10 Avionics SCOE Cable Requirements

AVI-2155/CREATED/T

All interfaces external to the Avionics SCOE (Spacecraft Interfaces, EGSE Interfaces) shall be provisioned to an interface panel located at the rear (bottom) of the SCOE equipment rack.

AVI-2162/CREATED/R

Suitable interface cables shall be provided to connect the Avionics SCOE to the external EGSE and Spacecraft Interfaces.

AVI-2161/GSE-SYS-412/T,I

With the exception of the Power Simulation interfaces (Section 3.6.1) connection to the Spacecraft Interfaces shall be provided by a set of cables, 20m in length, to a dedicated Spacecraft Interface bracket using Amphenol type lockable connectors.

Note: These cables are shown as green in Figure 1.4-1, and are identified as 'EGSE Supplier Furnished Cables', marked "DR06" for the Avionics SCOE.*

AVI-4224/CREATED/T

The cables required for the Power Simulation connections to the Spacecraft harness (PCDU) shall be provided by a set of cables designed to meet the output impedance and power regulation requirements on the LCL Simulators (see Section 3.6.1).

AVI-4226/GSE-SYS-412/I,R

All cables provided for connections to the Spacecraft Interface (either directly or indirectly) shall be manufactured with golded pins/sockets to prevent Spacecraft skin connector contamination.

The ICD for the Avionics SCOE to Spacecraft Interface bracket / Spacecraft Harness cables will be defined by Astrium following Project KO.

Provision of cables from the Spacecraft Interface bracket to the Spacecraft Harness will be the responsibility of Astrium Ltd.

Note: These cables are shown as blue in Figure 1.4-1, and are identified as 'Astrium Furnished Cables', marked "DR16*" for the Avionics SCOE.

AVI-2913/GSE-SYS-412/T

The requirements of the Avionics SCOE to Spacecraft Interfaces shall be verified using cables of no less than 40m in length (with the exception of Power Simulation). Note: This to verify operation during Thermal Vacuum testing of the GAIA Spacecraft.

AVI-2157/CREATED/I

Connection to the CCS shall be provided by a single standard LAN Cable of length 15m for connection to the Gaia EGSE LAN Hub.

AVI-2160/CREATED/I

Connection to the Real Time Network HUB shall be provided by the fibre-optic (COTS) cable supplied with the selected RTN card.

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3.11 Avionics SCOE Self Test

AVI-2159/CREATED/T

In order to verify the operational status of the Avionics SCOE equipment and functions, a self test facility shall be required.

Note: This will not be used to verify any cable interfaces and will largely consist of internal self test routines.

AVI-3355/CREATED/T

It shall be possible to initiate an Avionics SCOE self test at any time to report the operational status of the equipments and functions.

AVI-3356/CREATED/T

It shall be possible to carry out an Avionics SCOE self test with all interfaces connected to the Spacecraft, without stimulating any of the interfaces.

AVI-3357/CREATED/T

Any Avionics SCOE equipment failure found during a self test shall be reported on the local controller.

AVI-3358/CREATED/T

The result of a self test shall be visible on the local controller at all times.

AVI-3359/CREATED/T

It shall be possible to continue to use the Avionics SCOE, following a self test failure, if the failure is verified by the system administrator.

AVI-3360/CREATED/T

It shall be possible to initiate an Avionics SCOE self test from the CCS.

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3.12 Avionics SCOE Validation Test

Avionics SCOE validation testing is defined as the process of verifying the functionality of the SCOE, with particular regard to meeting the specified requirements at the Spacecraft Interfaces.

Thus, a successful validation test gives confidence that the SCOE can be connected to the Spacecraft and perform with expected results.

AVI-3363/GSE-SYS-411/T,R

The Avionics SCOE supplier shall provide an automated test solution for validating the Avionics SCOE, which fulfils the following minimum objectives:

- *Proves the Spacecraft Interfaces meet the specifications herein provided.*
- *Verifies the Interfaces to the RTS and CCS.*

AVI-3364/CREATED/A,R

To achieve this, the supplier shall utilise existing resources wherever possible, such as:

- *Using stimulation interfaces to verify measurement interfaces (and vice versa).*
- *Using loopback techniques (to verify BUS, RS422 links etc.)*

AVI-3844/CREATED/R

All tools, test aids, cables and test stubs required to perform Avionics SCOE validation shall be delivered with the SCOE.

AVI-3845/CREATED/R

All associated costs for providing the Avionics SCOE Validation facility, including hardware, software and development costs, shall be provided in a separate Work Package (WP) of the subcontractor's proposal.

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4 CO-ENGINEERING ACTIVITY

Critical to the operation of the Avionics SCOE as a component of a distributed real-time system is the interface to the Real Time Simulator (RTS).

The RTS subcontractor has been instructed to lead the design and development of this interface.

The critical requirements identified in this document towards the development of this interface are the synchronisation of the RTS to the Avionics SCOE (defined in Section 3.5.2) and the actual interface itself (defined in Section 3.8).

AVI-2907/CREATED/R

The Avionics SCOE subcontractor shall concentrate the early development activities of this project towards these requirements.

AVI-2908/CREATED/R

At an appropriate time of this development, a co-engineering activity with the RTS supplier shall be started (with the RTS supplier leading the task) to establish the criteria for successful implementation of this interface.

AVI-2909/CREATED/R

The initial requirements of the co-engineering activity shall be to establish:

- *A draft ICD defining the data transfer requirements between the RTS and the Avionics SCOE.*
- *Suitable protocol and methods to transfer data between the RTS and the Avionics SCOE.*
- *Benchmark the expected data latency between the RTS Model I/O and the Avionics Hardware I/O.*

AVI-3846/CREATED/R

As an input to this first activity, the Avionics SCOE supplier shall produce an Avionics SCOE ICD defining the SCOE to Spacecraft interface requirements.

AVI-2910/CREATED/R

At a later stage in the development (and as agreed by the two subcontractors) the co-engineering activity shall perform an integration task between the RTS and the Avionics SCOE to verify the data exchange between the systems and benchmark the expected final performance as a distributed real-time system.

AVI-2914/CREATED/R

The integration task shall:

- *Establish initial calibration values for RTS Model I/O to Spacecraft I/O.*
- *Finalise the ICD between the RTS and the Avionics SCOE.*

On completion, the RTS ICD will come under the control of, and be issued by, Astrium Ltd as a document which covers all aspects of the RTS interface.

AVI-2911/CREATED/R

Acceptance testing of the delivered Avionics SCOE shall include verification of the correct operation of the Avionics SCOE integrated with the RTS.

AVI-2912/CREATED/R

As part of Astrium Ltd. activities towards integration of the overall Avionics Model test bench (AVM), the Avionics SCOE subcontractor shall provide 6 weeks support to this task in parallel with the RTS subcontractor.

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5 GENERAL DESIGN AND INTERFACE REQUIREMENTS

AVI-2153/CREATED/R

The design of the Avionics SCOE shall conform to the applicable requirements defined in the EGSE GDIR [AD02].

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6 PA REQUIREMENTS

AVI-216/CREATED/R

The Avionics SCOE shall satisfy the applicable PA requirements as defined in the Gaia PA Requirements for GSE [AD03] and the Gaia SW PA Requirements for GSE [AD04].

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7 VERIFICATION REQUIREMENTS

7.1 General

AVI-2086/CREATED/R

The contractor shall propose the verification program, which shall be subject to agreement by Astrium Ltd.

AVI-2087/CREATED/R

The verification process shall demonstrate conformance to applicable requirements. A satisfactory completion of the verification process is the basis for a contractual acceptance of the product by the customer.

The requirements of this specification and of the specifications referenced therein shall be subject to formal verification close out.

As far as equipment or software is rebuilt from lower level test equipment (e.g., unit tester), the formal verification of the corresponding functions may be achieved by demonstration of successful use in lower level integration and testing.

7.2 Test Equipment

AVI-2089/CREATED/R

Adequate test equipment and simulators shall be made available to support the verification process.

AVI-2090/CREATED/R

This test equipment need not necessarily be deliverable and may therefore be recruited from the suppliers laboratory inventory. Of particular importance is the simulation of the communication interface with the RTS and CCS. These shall be fully representative on all protocol layers including the physical interface.

7.3 Verification Program

AVI-2092/CREATED/R

The subcontractor shall establish a verification program that assures that

The product is in compliance with the specified requirements.
The design is qualified.
The product is in agreement with the qualified design, free from workmanship defects and acceptable for use.

Qualification is defined as the proof that a design fulfils the requirements with adequate margin. For reused software modules / components acceptance test reports / qualification test reports may be used to demonstrate compliance with the requirements stated. The subcontractor shall not be required to rerun acceptance / qualification tests for existing, reused software. In case reference is made to already performed and existing acceptance / qualification in the frame of other space programs, requirements tracing of the above RTS requirements to the existing test procedures and test result has to be provided as well as the existing test procedures and test reports themselves.

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7.4 Verification Process

AVI-2102/CREATED/R

The verification process activities shall be incrementally performed at different levels and in different stages applying a coherent bottom-up concept and using a suitable combination of different verification methods.

AVI-2103/CREATED/R

The verification process flow shall be subdivided into the following steps:

Identification and classification of all the requirements to be verified
Selection of verification criteria (methods/levels/stages) against identified requirements
Establishing the planning for the associated verification activities
Obtain customer concurrence
Performance of verification tasks and verification control
Completion of verification control and evidence for verification close-out
Customer review and final approval.

7.5 Project Specific Verification Requirements

AVI-2120/CREATED/

Requirements verification shall be controlled in accordance with the following methods: (listed in order of preference)

Test
Analysis
Review of Design
Inspection
Similarity

AVI-2132/CREATED/R

The contractor shall apply the verification methods, as defined in this specification, for each requirement (see Section 1.2).

AVI-2133/CREATED/R

The subcontractor shall establish the verification documentation as defined in the Document Delivery List of the Avionics SCOE SOW.

AVI-2134/CREATED/R

The subcontractor shall report the verification status for each requirement.

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7.6 Specific Requirements On Tests

7.6.1 General

AVI-2137/CREATED/R

All specific support test equipment must be compliant with the intended purpose, within its useful life and calibration.

AVI-2138/CREATED/R

For tests performed with automated test scripts, batch files or generally with software, the test procedures and reports shall provide the relevant test-step information in the software source code or in the printout/protocol of each test software item. The test report shall include configuration control information (compilation date, checksum, version or revision number, etc.) for each software item used for the reported test.

7.6.2 Avionics SCOE Functional Tests

AVI-2140/CREATED/R

The Avionics SCOE functional tests shall verify the operation, connectivity and functionality of each supplied Software Module and Spacecraft Interface.

7.6.3 Avionics SCOE to EGSE Interface Tests

AVI-2147/CREATED/R

The proposed test schedule shall include verification of the Avionics SCOE to EGSE Interfaces:

- *Avionics SCOE to CCS.*
- *Avionics SCOE to RTS*

For the Avionics SCOE to CCS Interface, this may be achieved with the use of hardware stubs simulating the missing EGSE (and initially for the RTS interface).

AVI-2149/CREATED/R

For the case of the RTS, final testing of the Avionics SCOE to RTS interfaces shall include testing with an actual RTS in the loop.

AVI-2150/CREATED/R

As a minimum these tests shall verify the operation of and bench-mark the achieved latency times, of:

- *RTS Models commanding Avionics SCOE outputs to the Spacecraft.*
- *Updates at the Avionics SCOE inputs being detected by the RTS Models.*
- *MIL-STD-1553B and SpaceWire BUS transfers.*

AVI-2151/CREATED/R

Final testing of the Avionics SCOE with the RTS shall be conducted on site at Astrium Ltd.

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8 MAINTENANCE & SPARES

AVI-2166/CREATED/R

The subcontractor shall propose a maintenance and spares policy based on the number and possible location of the Avionics SCOE to be supplied (as defined in the Statement of Work).

AVI-2167/CREATED/R

A maintenance and spares policy shall be proposed to ensure the requirements for 'Reliability and Availability' (Section 5.11) and 'Maintainability' (Section 5.12) of [AD02]) are met.

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9 LIST OF ACRONYMS

AD	Applicable Document
AIT	Assembly Integration and Test
AOCS	Attitude and Orbit Control Subsystem
AP	Application Program
API	Application Programming Interface
AVM	Avionics Model
BC	Bus Controller
C&C	Command and Control
CCS	Central Checkout System
CCSDS	Consultative Committee for Space Data Systems
CDU	Clock Distribution Unit
CDMU	Central Data Management Unit
CFE	Customer Furnished Equipment
CMD	Command
COTS	Commercial Of The Shelf
CPS	Chemical Propulsion System
CPU	Central Processor Unit
CSW	Central Software
DMA	Direct Memory Access
DSA	Deployable Sunshield Assembly
ECSS	European Cooperation for Space Standardization
EGSE	Electrical Ground Support Equipment
EIU	Electrical Interface Unit
EM	Engineering Model
EMC	Electromagnetic Compatibility
ESA	European Space Agency
FCL	Fixed Current Limiter
FM	Flight Model
FMECA	Failure Modes Effects & Criticality Analysis
FPA	Focal Plane Array
FSS	Fine Sun Sensor
FVB	Functional Validation Bench
GSE	Ground Support Equipment
H/W	Hardware
HK	House-Keeping
I/F	Interface
ICD	Interface Control Document
ID	Identifier
IP	Internet Protocol
LAN	Local Area Network
LCL	Latching Current Limiter
MDE	Mechanism Drive Electronics
MMI	Man-Machine Interface
MPS	Micropropulsion Subsystem
MSB	Most Significant Bit
MTBF	Mean Time Between Failure
N/A	Not Applicable
NTP	Network Time Protocol
OBC	On-board Computer
OS	Operating System
OVF	Operational Validation Facility
PA	Product Assurance
PAA	Phased Array Antenna

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PCDU	Power Control & Distribution Unit
PCI	Peripheral Component Interface
PDHU	Payload Data Handling Unit
PFM	Proto-Flight Model
PLM	Payload Module
PUS	Packet Utilisation Standard
QM	Qualification Model
RD	Reference Document
RF	Radio Frequency
RID	Report Identifier
RT	Remote Terminal
RTS	Real Time Simulator
S/W	Software
SCOE	Special Checkout Equipment
SD	Standards Document
SOW	Statement of Work
STR	Star Tracker
SVF	Software Verification Facility
SVM	Service Module
TBC	To be confirmed
TBD	To be defined
TC	Telecommand
TCP	Transmission Control Protocol
TM	Telemetry
TRSP	Transponder
TTC	Tracking, Telemetry & Command
UTC	Universal Time Coordinated
VPU	Video Processing Unit

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10 APPENDIX A

Table 10-1 summarises the data interfaces between the Avionics SCOE and the Spacecraft Interfaces. The contents of this table will be **TBC** until final selection of Spacecraft Units.

Interface Type	Code	Qty	Subsystem	Reference
Latching Current Limiter	LCL-A	17	PCDU	[AD06] Table 3.5-2
	LCL-B	10	PCDU	
	LCL-C	7	PCDU	
	LCL-D	2	PCDU	
	LCL-E	1	PCDU	
	LCL-F	1	PCDU	
Pulse Acquisition	SHP	96,96	EIU,CDMU	[AD06] Table 3.5-23
	LVC	18,16	CPS,MPS	[AD06] Table 3.5-35
	FCV	16,16	CPS,MPS	[AD06] Table 3.5-36
Pulse Generation	SHP	96	EIU	[AD06] Table 3.5-22
Bi-level Telemetry	BLD	32	EIU	[AD06] Table 3.5-33
Digital Input	CMOS (0 - 12V)	9	EIU (FSS)	AVI-753
Relay Simulation	RSA	105	EIU	[AD06] Table 3.5-28
	RSA	18	EIU (CPS)	
	RSA	5	EIU (SS)	
	RSA	2	CDMU	
	RSA	8	CDMU ALARMS)	
	RSA	16	MPS	
Analog Output	AN1	16	EIU	[AD06] Table 3.5-8
	AN2	30	EIU	[AD06] Table 3.5-10
	AN2	18	EIU (FSS)	
	AN2	16	MPS	
	AN3	20	CPS/MPS	[AD06] Table 3.5-12
Standard Balanced Digital Link	SBDL	4	SREM	[AD06] Table 3.5-5/6
	SBDL	6	GYROS	[AD06] Table 3.5-5/6
Pulse Per Second	PPS	2	CDMU	[AD06] Table 3.5-7 (as SBDL)

Table 10-1: Spacecraft Interface Summary Table

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11 APPENDIX B

Table 11-1 summarises the data interfaces between the RTS (Models) and the Avionics SCOE (Spacecraft Interfaces). These data are transferred across the Real Time Network under the control of the RTS (DMA read/write cycles).

The maximum update rate for the RTS is defined as 1/64 of the CSW Major Frame control cycle (nominally 64Hz). The rates herein specified are updates/Major Frame control cycle.

The contents of this table will be **TBC** until final selection of Spacecraft Units.

Interface Type	Function	Qty	RTS Model	Input/Output (to RTS)	Update Rate
Analog (12-Bit)	LCL Currents	38	PCDU	I	8
Boolean	LCL STATE	38	PCDU	I	8
MIL-STD-1553B	BUS I/O (serial buffer)	2+2	CDMU/1553	I/O	64
SpaceWire	BUS I/O (serial buffer)	2+2	CDMU/EIU	I/O	64
PacketWire	BUS I/O (serial buffer)	4+4	CDMU/PDHU	I/O	64
Boolean	Latch Valve Command	18,16	CPS,MPS	I	8
Boolean	Latch Valve Status	18,16	CPS,MPS	O	8
Analog (12-Bit)	Simulated Pressure	4,16	CPS,MPS	O	8
Integer (percent)	Integrated FCV Pulse	16,16	CPS,MPS	I	64
Analog (12-Bit)	Simulated Flow Rate	16	MPS	O	64
Analog (12-Bit)	FSS (Q1 - Q4) Detector Outputs	12	FSS1 - FSS3	O	8
Analog (12-Bit)	FSS (T1 - T4) Test Stimuli	12	FSS1 - FSS3	O	8
Analog (12-Bit)	FSS Sun Presence Signal	3	FSS1 - FSS3	O	8
Real (32-Bit)	Gyro Stim Rates	3+3	GYRO1 - GYRO3	O	8
Boolean	SHP Commands	192	CDMU/EIU	I	8
Boolean	Alarms	8	Various	O	8
Boolean	Bi-Level Telemetry Simulation	32	Various	O	8
Boolean	Sep Straps	5	Sep Strap	O	1
Boolean	Relay Simulation	105	Various	O	8
Analog (12-Bit)	Voltage Simulation	46	Various	O	8
Serial Link	BUS I/O (serial buffer)	2	SREM	I/O	1

Table 11-1: RTS Data Interface Summary Table

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